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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

BUR... OF ENTOMOLOGY
RECEIVED

May 13, 1918. 4:30 p.m.

Met in Doctor Hunter's room in the Bureau of Entomology in presence of the following:

Barber, Basseches, Böving, Craighead, Dietz, Gahan, Heinrich, Hoffman, Kotinsky, Pierce, Popenoe, Sasscer, Smith, Snodgrass, Snyder, Wood.

Doctor Pierce took the leadership to inform the class of the object and method of procedure by reading the memorandum prepared at the request and for the approval of Doctor Howard. In substance this is as follows:

There is a possibility of the Army here and abroad calling upon the entomological profession to furnish, before long, a large number of men informed on the subject of disease transmitting insects and the methods of controlling these insects. It is intended therefore by means of this class and through correspondence with field men to prepare as many as are willing to undertake such work.

Class to meet once a week (more often if conditions warrant it, was the sense of those present) for one hour Mondays.

In addition to those present, the following, by signing the memorandum, have also enrolled in the class:

Morrison, Hyslop, Crawford, Caudell, Paine, Rohwer, Middleton.

A collection of insect transmitters of disease as well as specimens of the organisms they carry and the diseases produced is to be formed. Contributions for this exhibit, so far as possible, from private collections is urged.

A leader is to be chosen to give or provide for 20 minute talks

to be followed by discussion, all to be recorded and mimeographed for subsequent reference and use.

On motion of Mr.Heinrich, Doctor Pierce was chosen leader.

Mr.Kotinsky was elected secretary on motion of Mr.Sasscer.

As a preliminary, Doctor Pierce suggested that each member of the class allow himself ten minutes by the watch to write down what disease bearing insects he knows, the organism carried and the disease produced.

At 5 p.m. the class adjourned.

By the Secretary,

Jacob Kotinsky.

May 20, 1918. 4:30 p.m.

Lecture No.1. A General Survey of the Question -How Insects Can Carry or Cause Disease.

By W.Dwight Pierce.

Our nation is facing the greatest crisis in its existence. It must conserve its human energy and keep it at its greatest possible point of efficiency. This means above all that questions of health are foremost today. Entomology bears a twofold relationship to health. Adequate food supply upon which human and animal health are contingent is dependent to a greater or less degree upon insect depredations. This is the side of entomology in which most of us have been trained, that is, agricultural entomology. We have all of us recognized that insects do also bear a direct relationship to health but have more or less discounted the relationship, with the result that our appropriations for the study of insects affecting crops are 30 times as great as the appropriation for the study of insects affecting the health of man and animals. Our course of study is to cover this almost unworked field of medical entomology so that in the future we may assist in obtaining a better balance in the two great phases of economic entomology.

The scope of the course embraces studies of the relationship of insects to disease, the life history of the insects which cause disease, and the best methods of prevention of disease causation by insects. In view of the great military necessities of the day, we will direct our attention primarily to the military side of the question, but we will also take a view of the national, municipal and domestic problems.

In my opinion the future will see a group of professional sanitary entomologists who will give their service to solve the insect problems of municipalities and communities, as well as household problems. Perhaps members of this class may become the leaders in that profession. Municipal entomology

has already been recognized in a small way by certain cities. It will become better known only by the work of entomologists themselves who are men of vision. The problems involved in entomological sanitation demand an intensive and specialized training which none of us received in school. If we would fit ourselves for such work it will demand great effort on our part. We have that essential knowledge of insects which must come first, but most of us left school before medical entomology became a recognized science.

Granting that each of us is more or less informed on the subject of how insects may carry or cause disease, it stillseems advisable to attempt an orderly arrangement of our knowledge of the subject.

How Insects Can Carry or Cause Disease.

Long before any one knew of causative organisms in medicine it was recognized that insects might be productive of disease. We may therefore assume as our first category the disease actually caused by the insects themselves.

I. Diseases caused directly by insects. We must recognize for the sake of arrangement, all pathological conditions brought about by insects whether of a serious nature or not.

1. Entomophobia. The fear of insects both harmless and harmful, is a common ailment, amounting in many people to an obsession. I know of a young lady who became so frantic over the presence of a huge dragon fly in the automobile that the attempt to catch it led to a serious accident. Many women become frantic at sight of large insects and I have even seen men lose all sense of courage in the presence of an unknown species of insect. Obviously only patient and tactful education can ever cure such an obsession.

2. Annoyance and worry. We have all probably experienced a sense of annoyance, amounting sometimes to worry, from insects. It frequently happens

that the annoyance increases to the point of causing acute nervous troubles, and it is quite conceivable might lead to insanity with certain people. Animals are frequently driven frantic by insects and lose all control of themselves. We may classify these different cases of insect annoyance in accordance with the sense which perceives it and communicates its sensations to the brain, that is annoyances originating through sight, memory and imagination, sound, smell, taste and feeling. Sight worry is initiated by the occurrence of unwanted insects in one's home or garden, or by their constant swarming about one until patience is exhausted and one loses control of their nerves. A recently recorded case tells of a lady whose house was badly infested with book lice and who was fast becoming a nervous wreck when entomological service was sought and the house freed of its pests. The constant moving of streams of ants across a floor, the sight of bed bugs or fleas, and many other common occurrences may cause a nervous person great perturbation. Memory and imagination worry may be exemplified by the person impressed by anti-house fly propaganda whose imagination sees on every fly multitudes of fatal disease germs. A person once injured by an insect will often experience acute revulsions of feeling on sight of another similar insect. Sound worry such as that induced by the singing of mosquitoes or the buzzing of horse flies will often lead to insomnia and in the cases of animals will cause great uneasiness. Smell annoyance or worry from insects often takes the form of great embarrassment. A few years ago in Dallas, Calosoma beetles were so numerous that people walking on the streets frequently would have one alight on them and in brushing the beetle off would cause it to expel a sufficient quantity of liquid to make the person's presence undesirable in polite society. Many people are so sensitive to bed bug odors that when they sleep in infested rooms are constantly aware of the odor

and are possessed of a fear that they will be attacked by the bugs. Taste annoyance is often caused by eating berries containing bugs or which bugs have depredated. This may often cause nausea. Finally there is the worry aroused by contact of insects, the tingling sensation from insects crawling on the body, the peppery sting of gnats and mosquitoes, the itching sensationsfrom vermin. Insomnia is a frequent result of such attacks.

We may have thus as results of insect annoyance, worry,nervous exhaustion, excitability, halucinations, frenzy,insanity,nausea,insomnia and nervous chills.

3. Accidental injury to sense organs. There are numerous cases on record of insects accidentally obtaining access to the ear or nose and causing a stoppage of these organs, or of insects flying into the eyes causing severe irritation or even blindness. Certain species of gnats are especially annoying when there is any kind of catarrhal affection of these organs. Myriapods have frequently been recorded entering the nose.

4. Poisoning. Insects and the related arthropods may poison in a variety of ways. The bite of the tick, flea,spider,mosquito,horse fly,etc., may cause a severe local irritation and poisoning. The poisonous centipedes have a poison sac opening on the front pair of legs. The scorpion stings with the tip of its tail. The bee, wasp and ant sting with the ovipositor. Many of these injuries are very painful. Certain lepidopterous larvae are provided with barbed hairs which contain poisonous secretions, as the brown tail moth larva. Some insects emit poisonous secretions which blister. Some of the South American honey bees store poisonous honey.

5. Paralysis. The bite of several species of ticks causes a paralysis which often results in death. Some ants, bees and wasps inflict such a poisonous sting that temporary paralysis of the limb follows.

6. Dermatosis. Direct attack upon the body of men and animals and parasitism therein is not unusual. We have as striking examples the dermatoses caused by lice, by the chigoe, the red bug, the Dermatobia hominis, creeping worms, scab and itch mites. Many of these attacks have serious after results, as for instance an acute attack by the chigoe may result in ainhum, the loss of a toe or a foot. Many secondary diseases obtain access to the body through the skin attack of the insect.

7. Myiasis and similar internal attacks. Under this heading are to be considered those cases of insects breeding in the internal organs of the body. Insects have been recorded breeding in all of the organs of the head, in the intestinal canal, the reproductive organs and the body wall. When the insect is a fly the disease is called Myiasis. And when a beetle is the cause ~~of~~ the disease is called canthariasis, and if lepidopterous larvae is responsible it is known as scholeciasis. Many species of flies have been recorded as breeding in the human body. These will be studied in detail in a later lesson

II. Diseases carried by insects. The manner in which insects may carry disease are very diverse, due to the great differences not only in the habits of the insects, but also of the organisms and the hosts.

1. Diseases carried by insects to food. When insects carry disease germs to food or water we speak of the transmission as contaminative. Contaminative transmission of disease organisms to food by insects is naturally the simplest manner of transmission. This is necessarily done by insects which frequent excretionary substances and also visit foods, such as certain flies,ants, roaches, and beetles. It is obvious that we must look upon all insects which breed in fecal matter, sputum, etc., as potential disease

carriers. Considerable research has already been conducted to prove the actual role of many species of coprophagous insects. The role of the carriermay either be mechanical or biological.

Two large groups of disease organisms are transmitted by insects which exercise apparently only a mechanical role. These are bacteria and certain parasitic worms. Many of the bacteria may be taken up by fly and beetle larvae, and by adult flies, beetles, roaches and ants and carried on the body or ingested and pass through the body and out in the feces without modification or multiplication. A number of species of parasitic worms may be taken up in the egg stage by insects and deposited in the insect's feces.

Other organisms which are carried by insects to food pass part of their life history in the insects. Such are many of the nematodes ingested by coprophagous insects and later eaten by mammals.

2. Diseases carried by insects to wounds. We can make the same division of these diseases into mechanical and biological carriage. The transmission of anthrax, leprosy, ophthalmia, and such diseases from sore to sore or from excreta to sore is purely mechanical. When the organism passes part of its life cycle in the insect we might call the transmission biological. As examples of such types of transmission we may cite probably European relapsing fever and trench fever, louse borne diseases which gain access to the body by scratching in fragments of the lice or their excreta.

3. Disease gaining access through direct attack of insect. Most of the protozoal diseases and some of the parasitic worms gain access to the body of the vertebrate host by direct inoculation or indirectly at the time of feeding when the organism is taken up by the insect and passes its

development in the insect body and finally reappears in the salivary or some other position adjoining the mouth parts the inoculation occurs during the blood feast. Such is the inoculation of malaria, yellow fever. Rocky Mountain spotted fever. But other disease organisms pass through the intestinal canal of the insect and out of the feces and yet obtain access to the wound by being washed into it by body secretions of the insect as is the case of the organism of African relapsing fever inoculated by the tick Ornithodoros moubata.

WHY IT IS NECESSARY TO KNOW HOW INSECTS CARRY DISEASE.

In the foregoing discussion I have attempted to analyze the methods by which insects can cause or carry disease. This class is studying the subject from the practical side of the question. We must know the why and the wherefore and the what to do.

Without a conception of the role of the insect we cannot give sufficient force to our arguments or reasons for taking a particular course of action. For instance if we were merely to go before the inhabitants of a Montana valley suffering from Rocky Mountain spotted fever and say we are going to put down this epidemic, you must dip your horses and trap all the rabbits and rodents on your place, what kind of an answer would we get? If we had stepped into New Orleans on the announcement of a plague case and ordered everybody to rat-proof their cellars, without further reason, we would have been driven away.

If any of you become Army sanitary officers and report to your superior that a certain thing must be done, requiring a considerable outlay of money and a good many men, you must be able to give him a strong forceful argument to prove that you are right. Army officers want brief answers. You must

have your information on the tip of your tongue.

You have seen by the discussion that the bites of insects must be avoided. It is a big proposition to prevent the biting of thousands of men by blood sucking insects. To do this you must immediately set about to learn the blood sucking fauna about you. Without a knowledge of how mosquitoes, horse flies,bed bugs, lice, stable flies, gnats and ticks breed you can scarcely proceed to prevent their breeding and consequently cannot protect the men from bites.

You must prevent insects from coming in contact with wounds. You must keep food untouched by anything in the form of insect life. Insects must not be tolerated in dwellings, no matter whether there is evidence against them or not. There is evidence against most of them.

The animals must likewise be kept as free as possible from insects. Some day we will recognize that stables should be as well proofed against flies as dwellings are now. There are more inducements for flies and other noxious insects around a stable than anywhere else, and the stable is therefore the direct or indirect source of many of our troubles. The measures necessary for holding down insect infestation of stable and barn yards are therefore of primary importance. But to emphasize this importance there must be back of every measure taken or recommended an argument in the form of a proof of damger if the measure is not carried out.

As all of the subjects briefly touched upon in this lecture will be studied more fully in later meetings. I will merely present for your use a tabulation of the points mentioned with a few striking examples of each.

<u>How insects can carry disease.</u>

I. Diseases caused directly by insects.

1. Entomophobia. Fear of any form of insect life.
2. Annoyance and worry originating through,
   a. Sight-resulting in nervous troubles.
      a.1. Repugnant insect forms-grotesque worms,walking sticks,etc.
      a.2. Insects in the house-ants - bedbugs-roaches.
      a.3. Insects in the garden -potato beetles-lice.
      a.4. Insects swarming-termites,flights of leaf hoppers,beetles etc.
   b. Memory and imagination-resulting in halucinations,revulsions,etc.
      b.1 Memory of some accident or unpleasantness due to insects.
      b.2 Imagination of disease carriage which may cause nausea, insane fear or anger.
   c. Sound - resulting in insomnia.
      c.1. Humming or buzzing of insects.
   d. Smell - resulting in embarrassment or nausea.
      d.1. The odors of Cakosoma, Cimex,other bugs and beetles.
   e. Taste - resulting in nausea.
      e.1. Eating insects infesting food.
      e.2 Eating foods polluted by excretions of odoriferous insects.
   f. Contact - resulting in nervous itching,tingling,insomnia.
      f.1. Crawling of fleas and bugs on the body.
      f.2. Torment from bites of gnats and mosquitoes.
3. Accidental injury to sense organs resulting often in surgical operations.
   a. Injury to eyes - gnats flying in, ants crawling in during sleep.
   b. Injury to ear, gnats flying in, ants crawling in during sleep.
   c. Injury to nose, gnats flying in, ants crawling in during sleep.
4. Poisoning - resulting in rash, sometimes death.
   a. Poisonous bite (sometimes fatal),ticks,fleas,spiders,mosquitoes, horse flies,beetles.
   b. Poisonous glands on feet -centipedes have poison sac on first pair of legs.
   c. Poisonous stinging tail-scorpion.
   d. Poisonous ovipositor-bees,wasps,ants.
   e. Poisonous hairs -brown tail moth,larvae Lagoa caterpillars, Hyperchiria io worms.
   f. Poisonous secretions -meloid beetles.
   g. Poisonous honey (sometimes fatal) certain South American Trigona.
5. Paralysis.
   a. Caused by bite of ticks (often fatal)-Dermacentor.venustus or andersoni, certain species of African or Australian ticks.
   b. Caused by sting - the ant Pogonomyrmex barbatus.
6. Dermatosis.
   a. Burrowing in by chigoe somtimes causing ainhum.
   b. Dermatitis-caused by red bugs (Trombidium irritans).
   c. Scab and itch mites -Psoroptes, Demodex,Sarcoptes.
   d. Bots, creeping worms,Gastrophilus,Oestrus,Dermatobia hominis.
   e. Dermal myiasis -blow flies,Calliphora,Sarcophaga,Lucilia.
7. Internal attacks.
   a. Myiasis - attacks by fly larvae (Calliphora,Sarcophaga, Lucilia,Musca,etc.
      a.1. Otomyiasis -attack in the ear.
      b.1. Vaginomyiasis-attack in the vagina.
      c.1. Gastro-intestinal myiasis-attack in the intestinal canal.
      d.1. Cephalomyiasis-attack in the interior of the head.

b. Scholeciasis-accidental ingestion of lepidopterous larvae - such as the cabbage caterpillar, Pieris brassicae.
c. Canthariasis-accidental ingestion of beetle larvae, as Blaps mortisaga, Nitidula bipustulata, etc.

II. Diseases carried by insects

1. Carried to food.
   a. Mechanical carriage.
      a.1. From sputum -tuberculosis bacillus carried by house fly.
      b.1. From excreta-typhoid fever bacillus carried by house fly-hookworm eggs carried by the house fly.
   b. Biological carriage.
      a.1. From excreta-the beetle Aphodius castaneus takes up the eggs of the pig worm Arduenna strongylina, and the worm develops to a certain stage when it is taken up by the pig in eating the beetle.
2. Carried to wounds.
   a. Mechanical carriage.
      a.1. From carcasses-anthrax bacillus carried by blow flies.
      b.1. From wounds, -leprosy bacillus carried by flies.
   b. Biological carriage.
      a.1. Trench fever-enters the body by being scratched into the flesh in louse excreta or bodies.
3. Gaining access by direct attack.
   a. Direct inoculation (many examples).
      a.1. Malaria germs inoculated by mosquitoes (Anopheles spp.)
      a.2. Rocky Mountain spotted fever virus inoculated by Dermacentor venustus.
      a.3. Bubonic plague bacillus inoculated by rat fleas.
   b. Indirect inoculation.
      a.1. The Spiroschaudinnia Duttoni organism of African relapsing fever is washed into the punctures by a coxal fluid.

ASSIGNMENT.

We will make a survey of unsanitary entomological conditions in our own home vicinity. A map of the District will be kept in the office and all reports of bad breeding places of flies or mosquitoes etc., will be marked according to the species reported. If you do not know the species, put the larvae in a small breeding jar and carry them to maturity saving cast skins when possible. If you find any especially bad entomological conditions, write a brief report. Bed bugs, fleas, roaches, lice flies and mosquitoes should be reported.

If any of the men have boats I would like to have them look into the mosquito possibilities in the inlets along the river near the camps with a view to suggesting a possible means of handling the mosquitoes after the vegetation gets thick. Are any mosquitoes breeding there now?

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BUREAU OF ENTOMOLOGY
★ MAY 27 1918 ★
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PROCEEDINGS OF THE CLASS FORMED TO STUDY
THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

May 20, 1918. 3:30 p.m.

The second session of the class in Entomology of Disease, Hygiene and Sanitation was held in Doctor Hunter's office. Doctor Howard's approval made the session possible at the above hour. The following members attended: H.S.Barber, O.H.Basseches, A.Böving, T.C.Craighead, A.N. Caudell, H.F.Dietz, E.H.Dusham, A.B.Gahan, Carl Heinrich, W.A.Hoffman, J.Kotinsky, W.M.Mann, Miss M.L.Moles, W.Middleton, H.Morrison, J.A.Nelson, C.H.Popenoe, W.D.Pierce, Miss E.S.Reed, S.A.Rohwer, H.L.Sanford, E.R. Sasscer, J.D. Smith, R.E.Snodgrass, T.E.Snyder, A.T.Speare, M.Swartzell, C.A.Weigel, G.F.White, W.B.Wood. Mr.Paine wrote to the secretary regretting unavoidable absence.

Ten minutes was allowed for the assignment to those who failed to do so in advance.

Doctor Pierce, the leader, read a lecture entitled:"A General Survey of the Question, How Insects Can Carry or Cause Disease", which lasted exactly twenty minutes.

Mr. Craighead then read the report on a visit to Camp Humphreys summarized as follows:

On May 14, Doctor Pierce, Messrs.Middleton and Craighead visited Camp A.A.Humphreys as guests of Major Lund and Lieut.Gibson. Lieut.Gibson is in charge of all entomological questions concerned with the sanitary problems of the camp. He escorted the visitors over nearly the entire camp grounds and explained the sanitation work in detail.

Due to the location of the camp which is surrounded by swamp and dis-

sected by many water bearing ravines the mosquito control will be one of the most important problems. The disposal of garbage and manure and the installation of the water supply and sewage systems were discussed.

The visitors were very much impressed with the enormity of the entomological problems and the excellent manner in which Lieut. Gibson is meeting them. Lieut. Gibson stated that up to date there have been no louse troubles among the troops, but they were prepared to meet them.

By way of comment on this report, Mr.Wood related the complaint of a contractor of Camp Humphreys that he was unable to retain men longer than a week on account of the prevalence of lice. The fact that the military camp commandant did not have sufficient authority over the civilian workers or the teams used by them was commented on.

The leader urged boat owners to make observations on mosquitoes breeding in streams. He also read a letter from Sergt. R.C.Shannon, formerly of the Bureau, now at Camp Meade, in which the problems of waste disposal and the presence of flies, mosquitoes and Simulium at the camp are referred to. This led to remarks by Messrs.Barber, Heinrich, and others on the breeding places of Simulium. Mr. Barber reported captures of Simulium on the Smithsonian grounds.

The leader announced the assignment for next week: Survey of insect breeding insanitary conditions within reasonable radius of respective homes. Doctor Basseches, in this connection, called attention to mosquitoes breeding in the grounds of the Bureau. Also sarcophagids in dead rat found on the premises.

Mr. Snodgrass made inquiry regarding District of Columbia sanitation laws referring to insects and was assigned by the leader to look up the subject for the class.

Review of current literature:

Mr. Kotinsky was assigned the review of the paper on Dengue fever in Australia.

Mr. Middleton, a paper on flies and putrefaction.

Assembly adjourned at 4:30.

Jacob Kotinsky,

Secretary.

May 27,1918.

Lecture 2. A GENERAL SURVEY OF THE SERIOUSNESS OF INSECT BORNE DISEASES TO THE ARMIES.

W.Dwight Pierce.

As our course of study is directed primarily toward obtaining a thorough knowledge of the relations of insects to disease of armies, and the measures which must be taken to prevent these diseases it is eminently proper for us to take still another general survey before coming down to detailed studies of the various problems. Today's review will be on the practical side of the question. Let us endeavor to ascertain how serious insect transmitted diseases really are to armies.

Before we take up any specific diseases we may spend a little time in attempting to picture an army camp. The discussion immediately falls into two very distinct lines. We will first take up the army training and concentration camps, and second the active service camps and battle conditions.

Before the location of the average training camp we may assume that it was possible to deliberate more or less on the desirability of one or more sites and that in a general way drinking water and general health conditions were considered. Not infrequently some other consideration will outweigh sanitation, as when it is considered essential to place a camp near a certain city or on a certain waterway or railway. In such cases of expediency we are quite likely to find sanitation a serious problem from the outset.

The camp site is selected because of some important reason. From an entomologists view point a number of outstanding questions immediately arise as to this site. Is the ground open or wooded, level or sloping and well

drained? Are there water holes, running streams or swamps in the camp area or near-by? Are there farm houses,stables,or other buildings on the site and what is the entomological situation in these buildings? What disease carrying insects are naturally breeding about the camp site? If there has been any contagious disease of man or animals in the community before the camp was located the entomologist's concern is the greater. He should if possible learn the focus of that disease and the insect conditions of that focus. The original health conditions on the site may have a distinct bearing on later events.

The first arrivals at the camp site are contractors with multitudes of laborers and animals collected from everywhere, and from every stratum of society. There are few hygienic arrangements for these men, in fact, the contractors are aiming to obtain as large profits as possible,and therefore hold down the expenses for sanitary waste disposal. These laborers are almost certain to bring lice and bed bugs and probably fleas, possibly also scabies mites, on their bodies and clothes. Thrown together indiscriminately in hastily constructed barracks there is soon a general distribution of vermin. Their animals are quite likely to be infected with scabies mites and possibly other mites, with bots and ticks. The undisciplined assembling of many animals and carelessness about manure disposal offers great attractiveness to all flies and insects attracted by animals. It is probable that many dogs accompanying the laborers and contribute their quota of fleas. It is almost impossible with crude uneducated laboring men to get them to observe sanitary conditions. Indiscriminate defecation, the scattering of garbage, the accumulation of manure, personal uncleanliness all contribute to make the contractor camps sanitary sore spots.

Sooner or later the sanitarians arrive on the spot and very likely with

a squad or company of raw untrained labor troops and the clean-up begins. We can expect a constant lack of coordination however between the military and the civilian. As for example at Camp A.A.Humphreys the sanitary officers had constructed drainage ditches to carry off surplus standing water, but the laborers persisted in throwing scraps of wood, underbrush and waste into the ditches so that they were of no avail, or rather so that they formed traps for water pools. As another example we have the report of Lieut.Gibson that lice had not been found among the men but, on the contrary, the statement quoted by Mr.Wood that in some of the construction camps the lice were very bad, causing many laborers to quit. It was very easy to see the contrast between the stables of the contractors and the stables of the army close by each other. Of course the army sanitarians have supervision over these civilian camps, but they find difficulty in enforcing sanitation. When a camp is placed like Camp Humphreys on a tongue of land between two shallow bays of water that are known to fill up with vegetation and which furnish breeding places for millions of mosquitoes, and with typical swamp lands at the heads of these bays, we may readily see that the task of the sanitary officer is not an easy one. These bays are moreover at tidal level and the daily fluctuations of the water add complications to the drainage problem.

From the foregoing it may be seen that the stage is set in an army camp for sanitary troubles even before the troops arrive.

The tremendous speed of construction and the rapid arrivals of fresh contingents of troops and animals make the first months of the entomological sanitarian very busy ones. Common sense is one of the primary essentials in meeting the exigencies of the situation. The possibility of mosquito breeding must be kept at a minimum in spite of temporary drainage,

multitudes of barrow bits, tree stumps, fire-water barrels, etc. A system of manure, garbage, refuse and fecal disposal must be hastily devised and must keep pace with the increasing numbers of men and animals. Army camps in the war grow in such marvelous proportions that past experiences are of little avail. The man on the ground must be well grounded in the principles of entomological sanitation and must use his judgment for all it is worth.

The constant accessions in troops and raw recruits call for constant scouting and prophylaxis to prevent admission of vermin. The work against vermin almost necessitates a specialist to take care of it alone. In fact it were best if three entomological specialists were located in each camp, one looking after the suppression of water and moist earth breeding insects, one looking after the suppression of fecal, waste and manure breeding insects, and the third handling the vermin of the person and the barracks.

So serious is the vermin problem that elaborate measures have to be taken to combat it. The Germans have developed great vacuum tubes that will contain an entire railroad coach. The French and other nations have bath trains sufficient to handle the cleansing of thousands of men a day. The Russians and Roumanians developed sod heating houses for heat sterilization of clothing. Heat and steam sterilizing plants of many types have been devised. A tremendous amount of experimentation has been directed toward chemical cleansing of the clothing. The destruction of waste is also such an acute problem that many types of incinerators have resulted. Out of the mass of evidence which will accumulate on these impromptu devices probably certain standardized methods will ultimately be developed.

There is one peculiarity about military encampments which is decidedly bad from the standpoint of sanitation but which is probably dictated by other contingencies. This is the custom of grouping the barracks around the

parade ground and then placing each company's stables behind its own barracks. The result is that the camp is surrounded by a belt of foul smelling insect attracting stables. If in certain camps there is no especial reason for the proximity of the stables to the barracks, it would be a much better practice to separate the stables some distance from the barracks. At Camp Humphreys the Hospital is located outside the ring of stables, but not far from them.

As a camp becomes permanently organized the sewage system does away with early difficulties. Permanent incinerators, well kept drainage systems, organized removal of the manure by the quartermasters department, systematic inspection of quarters and grounds and systematic bathing and cleansing of clothing characterize the perfectly adjusted sanitation of a permanent camp

The actively engaged army however presents entirely different conditions. There is no possibility of developing sewage, but temporary latrines must be substituted. Manure and garbage cannot be farmed out to contractors but must be disposed of by hastily built incinerators or the manure stacked and treated to kill flies. Ditches and standing water can not be drained. They must be treated to kill insect life in them. Temporary hospitals abound and must be protected from flies and vermin. The men sleep out of doors or in scanty shelters, often in pig pens, barns, etc. Insect infestation in these must be reduced to a minimum. When lice abound, hastily constructed heating huts must be put up or the clothing treated by chemicals. The trenches and dugouts have to be sprayed with creosote oils to keep away flies and kill vermin. Terrible stenches arise from dead bodies and these must be buried or treated to prevent fly breeding. In other words everything here must be done hastily but effectively, for tomorrow the work may

have to be done all over somewhere beyond or behind. The larger the body of men assembled and the greater the carnage the worse are the diseases of all kinds and especially those carried by insects.

In the present war the greatest diseases are those borne by lice. In fact there is plenty of evidence that louse borne diseases have been among the worst in many wars of the past. Three serious diseases ravaging the trenches are carried only by lice -typhus fever, trench fever and relapsing fever (Spiroschaudinnia berbera, and S. carteri, and possibly also S. recurrentis). Millions of the servian nation were wiped out by typhus fever. The Roumanian nation a year ago was swept by typhus and relapsing fever. Russia, Germany, Austria and France have suffered terribly from these louse borne diseases. Trench fever has spread back from the trenches into the cities. And yet all of these diseases can be controlled absolutely by suppressing the lice. It is easy to see how serious it is if a case of any of these diseases enters the trenches. The lice spread from man to man, and they are noted for leaving a man with feverish conditions for a normal man.

Another disease which is especially bothersome in the trenches is scabies. Both horses and man are seriously afflicted with this mite disease, and special veterinary hospitals have been constructed solely for handling horse scabies.

In malarious countries where mosquitoes are breeding in great numbers, malaria is a very serious camp and army problem. Campaigns in tropical countries are endangered often also by yellow fever, dengue and filariasis, which are also mosquito borne diseases.

The troops engaged in Asia and some parts of the Mediterranean littoral have had to contend with the possibilities of plague outbreaks. Troops engaged in the African campaigns have had to deal with trypanosome and spiro-

chaete disease. Along the Mediterranean littoral papataci fever and tropical sore enter the arena of insect borne diseases especially needing to be guarded against.

You are all familiar with the disaster of our Spanish American war in which so many thousands were carried away by typhoid fever, dysentery and diarrhea, all fly borne diseases. In the present war, to these must be added Asiatic cholera also borne by the fly

The great quantity of carcasses on the battle field gives rise to myriads of flesh and carrion flies and as a consequence of the habit of these flies of attacking wounds of living people, there have been many cases of human as well as animal anthrax.

These are only the more important army diseases carried by insects. One of the greatest dangers to troops in active service lies in their moving into countries with obscure or little studied diseases, or diseases against which the men have had no chance to develop immunity. As for example a detachment of the British Army in Egypt was suddenly attacked by an outbreak of papatasii fever. In British East Africa the troops were affected by relapsing fever.

ASSIGNMENT.

Read up the literature available to you on the housefly especially Farmers' bulletin 851, also Department bulletin 14, 131,200,408.

Obtain a copy of Circular 61, Office of the Secretary if you do not already have it.

Write out answers to the following and return by June 10.

1. In army remount stations where the animals on the picket line have tramped the earth into a soft, manure and urine filled condition enabling flies to breed, what treatment would you suggest?

2. If a farmer has a contract for any garbage to be fed to his hogs what measures would you advise to prevent fly breeding?

3. What would you do to prevent flies from coming in contact with milk in a dairy during the milking time?

4. Can you find in the literature any reference to a repellent for application to milk cattle which will not taint the milk?

BUREAU OF ENTOMOLOGY
★ OCT 7 - 1918 ★
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PROCEEDINGS OF THE CLASS FORMED TO STUDY
THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

May 27, 1918. 3:30 p.m.

The third session of the class was held in Doctor Hunter's office in presence of the following: Basseches, Böving, Caudell, Dietz, Dusham, Gahan, Ginsburg, Heinrich, Hoffman, Kotinsky, Mann, Middleton, Moles, Morrison, Nelson, Paine, Perrine, Pierce, Reed, St.George, Sanford, Sasscer, Smith, Snodgrass, Snyder, Swartzell, Weigel, Whitcomb, White, Wood. 30 in all.

Dr. Pierce, the leader, opened the session by reading lecture No.2, entitled: "A General Survey of the Seriousness of Insect Borne Diseases to the Army".

At the conclusion of the lecture the leader called attention to the assignment for June 10 given on page 24.

In review of current literature on pertinent subjects, Mr.Middleton read his abstract of a paper on prevention of flies and putrefaction by Foreman and Graham-Smith, in which the general utility of coal tar creosote oils is pointed out. Dr.Pierce called special attention to the desirability conveyed to him by an army sanitarian of discovering a single substance of simple application and extensive usefulness. The creosoting system described in this paper partakes of that nature in that it kills flies and arrests putrefaction at the same time.

Mr.Kotinsky reviewed a paper on "Dengue in Australia" by Cleland and Bradley, in which the authors claimed to have established that Stegomyia fasciata, now known as Aedes argenteus Poirret, transmits Dengue fever. They base their claims on the fact that (1) the distribution of the two

coincides and (2) that such mosquitoes fed up on patients in 4 cases out of 7 inoculated persons they bit who were known to have been free from it. Culex fatigans, the other common household mosquito in Australia failed to do so in the similar experiments performed with it. Incidentally, Mr. Kotinsky related that Dengue is prevalent in Hawaii where Aedes argenteus does not occur.

The leader conducted the following short quiz. Correspondents who receive this will please sit down immediately with pencil and paper and answer the questions without looking up answers and mail to the secretary. Head the sheet, "Answers to class quiz questions"."

1. How can the house fly transmit disease?
2. What types of disease are transmitted by the house fly?
3. What kind of an insect carries tertian malaria?
4. How can you distinguish in general a malaria carrying insect from other related genera?
5. Is the transmission of malaria mechanical?
6. Where does the house fly breed?
7. How is yellow fever transmitted?
8. How is trench fever transmitted?
9. How is typhoid fever transmitted?
10. What disease is produced by the swallowing of live Dipterous larvae or eggs?

The quiz and result shows that we must read up on the subject, particularly the lectures; evidently what our chosen leader expects us to do.

Numerous copies of the Proceedings and lecture of preceding session with assignment attached were distributed to those present before adjournment at 5 p.m.

Members are urged to glance over the list of those present at meetings to insure correct registry; also not to fail to register in course of session.

When assigned a Review of Literature, please boil down to a minimum and leave with the secretary before the conclusion of the meeting for insert in the proceedings.

Jacon Kotinsky, Secretary.

June 3, 1918.

Lecture 3. LOUSE BORNE DISEASES.

The insects of the order Anoplura or Siphunculata, commonly called sucking lice or vermin, and of the order Mallophaga, called biting lice, are responsible for several very serious diseases of man and animals. In view of the fact that they are primarily responsible for at least three of the most important army diseases of this war, we are studying them ahead of the house fly, often rated as the greatest scourge of mankind. The louse problem is not so well known as those of the fly and mosquito and consequently it is advisable for us to become familiar with it first.

EFFECTS OF LOUSE ATTACK.

The attack of lice on the body is in itself exceedingly annoying and leads to a great deal of itching and scratching. The attack by the body louse, Pediculus corporis DeGeer, or as it is now known by Nuttall (1917), Pediculus humanus var. corporis, is known as pediculosis corporis. The attack by the head louse, Pediculus humanus Linnaeus, commonly known as capitis DeGeer is called pediculosis capitis. Attack by the pubic louse, Phthirus pubis Linnaeus, is known as phthiriasis.

Skin diseases. The bites of these lice produce minute haemorrhagic spots which are accompanied by more or less urticaria, the itching leading to scratching. In tramps, chronic drunkards and vagabonds who have harbored lice for many years, the skin over the areas most frequently bitten becomes rough, hardened and deeply pigmented, a condition known as morbus errorum or vagabond's disease. This skin pigmentation, also called melanodermia, may extend to the mucous membranes, being visible in the mouth and is sometimes confused with Addison's disease (Nuttall 1917).

Among the results of infection according to Nuttall (1917) are various forms of dermatitis, such as purigo senilis, urticaria, eczema, porrigo, and pustular dermatitis. The urticaria and eczema are probably due directly to the lice themselves and their secretions. Peacock has found louse rash distressingly common among the British troops. Various authors have claimed that the lice sometimes burrow under the epidermis forming so-called "covered louse-ulcers", which on opening liberate many lice. Railliet has seen Haematopinus form real subepidermal nests in an old horse. As results of eczema or pustular dermatitis of the scalp the exudations of the skin lead to formation of scabs and crusts in the hair especially at the nape of the neck, and this condition has been called plica pollonica because it is so frequently observed among the poor Jewish population of Poland. (Nuttall 1917).

Eczema. The scratching of the wounds is quite likely to lead to serious infections. Dewevre in 1892 proved that the head lice can convey impetigo contagiosa by removing lice from impetigo cases and placing them on the heads of healthy children who some days later developed the disease. This claim has been supported by various authors. Aubert in 1879 claimed that lice spread impetigo, favus, pityriasis, etc. MacGregor (1917) records Diplococcus pemphigi contagiosi Manson, the causative organism of tropical impetigo as positively carried by lice. It is a different disease from impetigo contagiosa. Castellani and Chalmers treat this disease under the name pyosis mansoni and consider it to be caused by Staphylococcus pyogenes aureus and albus. Favus is a disease of the hair follicles caused by the fungus Achorion schoenleini Lebert. The various types of pityriasis are caused by fungi of the genus Malassezia.

Sobel in 1913 as a result of eleven years experience with New York school children states that head lice are the indirect cause of pyogenic infection, frequently leading to involvement of the lymphatic glands followed by suppuration, and that lice also indirectly cause impetigo contagiosa, dermatitis, furunculosis, eczema and folliculitis. Pinkus in 1915 describes similar results and states that the inflammation of the scalp may lead to the falling out of the hair.

Septicaemia. In experiments conducted by Widmann (1915), he succeeded in making lice bite mice in which he had produced Pneumococcus septicaemia. He could not infect other mice by means of the louse bites but found the louse feces infective during the first 24 hours. The cocci were confined to the intestinal tract and did not multiply therein. He also failed to transmit Staphylococcus infection by louse bite but recovered living cocci from the louse feces after 60 hours but not later. In view of recent findings with other louse-borne diseases we may expect that infection could have been obtained by slightly abraiding the surface on which the lice had defecated.

Conjunctivitis. DeFont Reaulx (1912) and other writers regard head lice as the cause of phlyctenular conjunctivitis, and Hudson (1914) states that its sequela phlyctenular keratitis prevails among Board School children in England, causing much suffering and corneal scars with resultant disabilities. He refers severer cases primarily to head lice, infective material being carried from the scalp to the eyes by the hands.

Plague. Swellengrebel and Otten (1914) experimenting with clothes lice from plague patients in Dutch East India, and DeRaadt (1916) have succeeded in causing death by plague in experimental animals by subcutaneous inoculations of crushed lice. Herzog in Manila found Bacillus pestis in three head lice from a child dead of plague (Bulloch and Douglas, 1909). There is no

evidence that plague can be carried by the bite of lice.

Typhoid fever. In like manner Abe (1907) claims to have discovered Bacillus typhosus from body and head lice fed on typhoid fever patients in 75 per cent of the insects examined.

Leprosy; McCoy and Clegg (1912) have likewise found Bacillus leprae in two head lice out of many examined from patients suffering with leprosy.

Cerebrospinal meningitis. Pizzini (1917) found a strong parallel in two Italian outbreaks of meningitis with the occurrence of lice on soldiers and civilians who contracted the disease. Some patients were found to have in their underclothing louse vectors of the Meningocccus, more properly called Diplococcus intra-cellularis meningitidis Weichselbaum, or they were found to have handled garments infested with such lice. The months during which the disease is prevalent are those during which lice are definitely parasitic.

All of the various cases cited are probably to be considered purely as examples of mechanical transmission by scratching of the feces of the lice containing the organism, into the skin. The organisms of impetigo contagiosa, tropical impetigo, favus, pityriasis, Pneumococcus and Streptococcus septicaemias, phlyctenular conjunctivitis and keratitis, plague, typhoid fever, leprosy, and meningitis are all bacteria or fungi. It is to be hoped that experiments in inoculation of feces will be carried out with those organisms in which the exact role of the louse is still undetermined. The almost irresistable desire to scratch a louse bite should make louse transmission of any organism taken up from the blood, which can successfully pass through the lice into their feces a very easy matter. In case of typhoid if there is transmission it might be through soiling

fingers on crushed lice. This consideration leads me to suggest that some one take up the question of louse transmission of gonorrhoea, poleomyelitis, pellagra, and small pox, giving special attention to inoculation of infected feces.

Beri-beri. In this connection it may be mentioned that Manson (1909) has advanced the hypothesis that lice may possibly transmit beri-beri, a disease whose cause is undetermined. Daniels conducted an unsuccessful attempt in transmitting beri-beri from man to an orang-outang by means of lice, due probably to the inability of the lice to live on the host. (Castellani and Chalmers,p.1216.) He did not attempt inoculation of the feces, apparently expecting to convey the disease by the louse bite.

TRANSMISSION OF DISEASES OF UNKNOWN ORIGIN.

Typhus fever. Acting on the suggestion of Sergent and Foley in Algeria, the transmission of typhus fever by the louse was first proven by Nicolle, Comte and Conseil (1909) working in Tunis. They successfully transmitted typhus from monkey to monkey by means of the bites of infected lice (Pediculus corporis) that had fed on typhus fever patient 1-7 days previously. A few months later Ricketts and Wilder (1910) working independently in Mexico reported successful infection of monkeys that were bitten by Pediculus corporis previously fed on typhus patients, and they also infected monkeys by placing the gut contents of such lice on scarified skin, three days after the lice had fed upon a typhus monkey.

Further proofs of transmission of typhus fever by louse bites were published by Wilder(1911), Goldberger (1912), and by Anderson and Goldberger (1912); proofs of transmission by inoculation of crushed lice were published by Wilder (1911), Goldberger (1912), Prowazek (1913) and by Nicolle,

Blanc and Conseil (1914); the last named authors proved the feces of lice when inoculated were infective at least 6 days after the lice had fed on a typhus fever patient.

Wilder (1911), Sergent, Foley and Vialatte (1914) and Da Rocha Lima (1916) claim that typhus fever is hereditarily transmitted by lice but Anderson and Goldberger (1912) and Nicolle, Blanc and Conseil (1914) hold that there is no proof of hereditary transmission.

No definite organism has been finally fixed on as the cause of typhus fever although several have been described. Podies called Rickettsia provazeki Rocha-Lima are regarded by Rocha-Lima (1916), Moeller (1916) and others as the causative organism and it is claimed that they undergo multiplication in the cells of the midgut of infected lice. Plotz (1914) and others regard Bacillus typhi-exanthematici as the cause. Stempell (1916) has described a Protozoan, Strickeria jürgensi which he suspects to be the cause of typhus, and claims that it undergoes part of its development in the intestine of Pediculus humanus, and is sometimes transmitted to man in large numbers. Rabinowitch (1914-1916) regards Diplobacillus exanthematicus as the cause; Penfold (1916) describes a Micrococcus; Proescher (1915) describes minute Diplococci and Diplobacilli as present in the endothelial cells of the human subject. Finally Futaki (1917) has described Spiroschaudinnia exanthematotyphi from the liver and urine of patients dying of typhus and has found the same organism in lice. As this disease can be conveyed either through the bite, the crushed body or the feces, it would most likely be caused by a protozoan which can migrate from the gut to the salivary glands. It is of interest to note the records of the various spirochaete diseases mentioned below.

Trench fever. This disease has only recently been recognized, having passed even in the early days of the war under the initials P.U.O. or pyrexia of unknown origin. Many of the greatest investigators in the various armies have been concentrating attention on this baffling disease of the trenches which stands among the highest of the disabling diseases of the Western front. The first record of the connection of the louse was contained in a statement of Davies and Weldon in 1917 that one of them had produced the disease in himself by permitting infected lice (Pediculus humanus)to bite him. The incubation period was 12 days. Early in 1918 two separate committees, the British under Sir David Bruce and the American under Dr.R.P.Strong succeeded in proving louse transmission. The English committee (Bruce 1918) in an experiment in which lice were crushed on a scarified area of skin of volunteer patients incubated the disease in eight and ten days. In experiments with the feces of lice fed on trench fever patients, a small amount of dried excreta rubbed on a scarified area of skin, incubated the disease in three men on the sixth, seventh and eighth days. Blood from one of these men on the second day of fever inoculated in another volunteer produced a typical attack after an incubation period of five days. As the lice will usually leave a man with fever and migrate to a man with normal temperature it is easy to see how the disease is propagated

The report of the American committee has not yet come to hand although preliminary statements (Lambert 1918) have been published in the papers. These reports infer that the organism has been isolated. For the work of the American committee a large number of volunteers was obtained from the army.

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The Haemogregarina gracilis Wenyon suspected to be connected with the disease has since been proven not to have any connection.

Volhynian Fever. This obscure European fever also called the Hiss-Werner disease, is claimed by Töpfer (1916) to be carried by lice. Jungmann and Kuczynski (1917) have confirmed this, claiming that an early diagnosis of Volhynian fever is possible by examination of the lice taken from patients. Da Rocha-Lima (1917) points out the similarity of this disease to typhus fever, and describes Rickettsia pediculi which he believes is the causative organism, and which develops on the epithelial cells in the lumen of the stomach of the louse.

Five-day Fever. This fever, also called Febris quintana is very little known. Werner and Benzler (1917) describe two cases of transmission by bites of lice.

TRANSMISSION OF PROTOZOAN DISEASES.

Asiatic Relapsing Fever. Mackie (1907) in India was the first to investigate the transmission of relapsing fever by lice. He found a striking coincidence between the cases of fever among Indian school children and the prevalence of lice (Pediculus corporis). Mackie found the spirochaete in 14 per cent of the lice from the boys and 2.7 per cent of the lice from the girls. He noted that the spirochaetes multiplied within the gut of the lice and that they could be found in the ovary, testis and Malpighian tubules of the insects, but did not find them in the ova laid by infected insects. Bisset (1914) only found Spirochaetes in the gut and coelomic cavity of the lice. Asiatic relapsing fever is caused by Spiro schaudinnia carteri Mackie, which is considered as a biological species, not morphologically separable from S. recurrentis.

North African Relapsing Fever. Following up Mackie's work, Sergent

and Foley (1908) in Algeria carried out experiments with lice and obtained positive results by the inoculation of a monkey (Cynomolgus cynocephalus) with a single crushed infected louse (Pediculus corporis). Pediculus humanus has also been recorded as an intermediate host. Nicoll, Blaizot and Conseil (1912) also working in North Africa found that when body lice were fed upon infected blood, the spirochaetes disappeared rapidly from the insects intestinal tract within 24 hours. On the eighth to tenth day, typical, active spirochaetes reappeared in the lice. Thousands of lice were allowed to bite monkeys and a man with only negative results. Infection was obtained in one of the authors by crushing an infected lice on excoriated skin, the incubation period of the fever being five days. They determined in one experiment that the infectivity of the lice was hereditarily transmitted. Eggs laid 12 to 20 days after the parent lice had fed on relapsing fever blood were placed at 28° C and began to hatch on the seventh day. The young larval lice and some unhatched eggs were now crushed and inoculated into a monkey which subsequently developed relapsing fever. The spirochaetes were not discoverable microscopically in the eggs. As the result of the work of Sergent, Foley,Nicolle, Blaizot, Conseil and others it is proven that the lice are infective though inconstantly up to five days after an infective meal, and constantly on the sixth day, although during this period spirochaetes are absent; on the 8th to 9th days the spirochaetes may or may not be present and infectivity is exceptional. After the spirochaetes become fully developed in the lice infectivity vanishes. They may be infective up to the 15th day. The apyrexial stage of the spirochaete in man and the developmental or granule stage in the insect are so minute that they have not yet been

demonstrated.

North African relapsing fever is caused by Spiroschaudinnia berbera Sergent and Foley, which is considered as a biological species, not morphologically separable from S. recurrentis.

European Relapsing Fever. Although many authors consider the above mentioned relapsing fevers as identical with the European fever, which is caused by Spiroschaudinnia recurrentis Lebert, the evidence of louse transmission was slow in coming. Mantsufel (1907) found that the rat louse, Polyplax spinulosus may carry the disease from rat to rat, and suggested that possibly Pediculus corporis could carry it to man. Other authors made similar suggestions. Finally Toyada (1914) found crushed lice infective for mice up to three days after they had fed on infective blood. Since the outbreak of the great war the conviction of the role of the louse as a vector of European relapsing fever has become very strong. In fact repressive measures used in Roumania against the louse were effective against the fever. This disease can also be carried by the bed bug, Cimex lectularius.

Relapsing Fever of Tropical Africa. This disease caused by Spiroschaudinnia duttoni Novy and Knapp, is normally transmitted to man by the tick Ornithodoros moubata, but Neumann (1909) found that it could occasionally be transmitted from rat to rat by means of the rat louse, Polyplax spinulosus.

Infective Jaundice. Infective or epidemic jaundice, also known as Weil's disease is caused by Spiroschaudinnia icterohaemorrhagiae Inada and Ido, and is infective to man and rats. In the European trenches the rat is regarded as the reservoir of the disease. The spirochaete is excreted by way of the urine or feces of rats or men and is consequently

easily communicated through the trenches. It is readily communicated through the mouth or through abrasions in the skin(Dawson,Hume and Bedson 1917). Stokes conducted negative experiments with Pediculus corporis, but these experiments were not directed toward obtaining infection through crushing or scratching lice or feces into abrasions of the skin. This phase of the subject will bear further investigation.

Indian Kala Azar. Tropical Leishmaniasis or Indian Kala Azar is caused by Leishmania donovani Laveran and Mesnil. The normal character is undetermined, but positive results have been obtained with the bed bugs, Cimex hemipterus and C. lectularius. Patton and also Mackie have failed to get results with lice. Possibly these failures were also due to the conduct of the biting experiments rather than scratching in experiments with lice and their feces. It would pay to reinvestigate the lice in connection with the disease.

Rat Trypanosomiasis. This disease is caused by Trypanosoma lewisi Kent, which is often nonpathogenic, but common to many rodents. It is transmitted by several species of fleas but Von Prowazek has demonstrated that it may also complete its development in the rat louse, Polyplax spinulosa. The rats become infected by licking up the insect dejections.

Jerboa anemia. The anemia of the jerboa, Gerbillus indicus is caused by Haemogregarina (Hepatogoon) gerbilli Christophers in India. The describer, Christophers (1905) believed that he found the cycle of sporogony in the rat louse Polyplax stephensi

Palm Squirrel anemia. The anemia of the palm squirrel, Funambulus pennatii in India is caused by Haemogregarina (Hepatozoon) funambuli Patton. The vermicules were found by Patton in the gut of the louse

(Haematopinus sp.) and also in the coelome, but further development was not observed.

Canine tapeworm. The dog tapeworm, Diplidium caninum may have as an intermediate host the biting louse of the dog, Trichodectes canis according to Melnikow, although it usually passes its intermediate stages in fleas.

LOUSE PARASITES.

Leptomonas pediculiFantham (Herpetomonas) is the only true louse parasite described. Fantham and Porter (1916) have even demonstrated this organism experimentally pathogenic to Mus musculus. It occurs in the alimentary tract of Pediculus corporis and P. humanus.

This completes the summary of the evidence which has so far been presented against the lice. There are many species of sucking lice of wild and domestic animals, and there are many obscure or little known animal diseases. It is naturally to be expected that the literature of animal disease transmission by lice will grow.

I have attempted also to show that the majority of the louse borne diseases pass through the body of the louse and out through the feces and that they gainaccess to the host in the following ways: the rubbing or scratching into a skin abrasion of infective portions of the insect body or its dried or fresh feces; the carrying of the contamination on fingers which have scratched the louse or its feces and transfer of the contamination on the fingers to the mouth or the eye; the licking up of the lice or their feces by animals which cleanse themselves with the tongue. Direct transmission by bite is apparently exceptional except possibly in typhus fever.

It remains therefore to reiterate that all types of skin diseases and

sus
blood diseases in which the louse might be expected should be reinvestigated in case the usual types of inoculation mentioned above have not been tried.

A bibliography is attached.

The next lecture will take up the habits of the lice and requirements for control.

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May 20,1918. Report 1.

Report of Trip to Camp A.A.Humphreys,Virginia,

Prepared by F.C. Craighead and W. Middleton.

On May 14, Dr.W.D.Pierce, F.C.Craighead and William Middleton, at the invitation of Major Lund and Lieutenant Gibson of the Sanitary Corps, U.S. Army, visited Camp A.A.Humphreys Va.

Camp Humphreys is located between Accotink and Mount Vernon on a projection of land surrounded by Gunston Grove, Potomac River and Dogue Creek. The camp proper covers about 7 to 8 square miles and is on the higher ground about 100 to 150 feet above the river. This area has a deep clay soil, giving a water retaining surface in all depressions and was originally entirely covered with a mixed stand of hardwood and pines.

Through the entire length of the camp extends a parade ground with the barracks situated along the sides. These buildings are frame, two stories high, well ventilated and with a large heater in the center of each floor. Each regiment has its own mess hall and kitchen in a screened building and beyond the barracks each regiment has its individual stables.

At present the camp is not much more than half finished, and the occupants are both military and civilian. The officers have no authority over the civilian workers and consequently the sanitary conditions are much worse now than they will be later. It is to be a training post for engineering and medical troops and when completed will accommodate about 18,000 men. However, it can be extended to hold 30,000.

The sanitary work of the camp is under the direction of Major Lund, who is assisted by Captain Thomas and Lieutenant Gibson. This work consists of providing a pure water supply, sewerage, manure and garbage disposal, and

insect control.

At present the water supply is obtained from wells situated at different places in the camp, but work is under progress to establish a filtration plant near Accotink, securing the water from Pohick Creek. The sewage system which is now being installed will empty into Dogue Creek. The temporary latrines consist of tents and wooden shelters covering a box over a hole in the ground. These boxes are absolutely fly proof even the seats being fitted with an automatically closing lid. Daily the boxes are removed and the pit burned out with straw and oil. After considerable use they are filled with earth and another station established. As these are often located at some distance from the barracks this arrangement is unsatisfactory at night.

The permanent latrines are being completed but will not be in use until the water and sewerage system is finished. These are rectangular wooden buildings having concrete floors. The contain several rows of seats, a series of showers, a wash room, and a boiler and heating apparatus. A separate seat is to be marked for subjects of venereal diseases. It is hoped that with the completion of these latrines the sewage problem will be permanently disposed of.

Lieut.Gibson is in charge of the entomological work and has absolutely full control and responsibility as to the means and methods of solving these problems. This work is entirely practical and to facilitate its execution he has under his immediate direction 150 negro troops. The problems confronting him are so intensely practical that no time for investigative or systematic work is available and his ingenuity is continually taxed in the application of recognized means of control to the particular features at hand.

The entomological work at Camp Humphreys may be divided into the following problems: mosquito control, louse and flea control, and the prevention of insect breeding in garbage, manure and other excrement.

Mosquito problem. The particular situation of the camp, surrounded by marshy land and with many ravines and stagnant pools, makes the mosquito problem the biggest from the entomological standpoint. These natural features of the camp make ideal breeding grounds for the mosquito and the control of these insects will be very difficult. To expedite this work Lieut. Gibson has divided the whole promontory into six districts, each in charge of a noncommissioned officer. The larger swamps surrounding the camp are to be made accessible to fish by canals. This work will be begun as soon as the men can be supplied with rubber boots and equipment. The entire camp is to be drained and the drainage canals, streams and small marshes are to be kept constantly clear. The removal of trees and construction work has made many pools of stagnant water around the camp. Eventually these will be filled in, but at present they are oiled at intervals of seven days. The oiling work is accomplished by spraying squads, consisting of a corporal in charge of two spraying men, one relief man and one pick and shovel man. At each buildig large barrels are kept filled with water for fire purposes. These barrels are also systematically oiled. On this trip no wrigglers or mosquitoes were observed but the men on the camp outskirts were reported to complain of the mosquitoes at night.

The Garbage Problem. The garbage originally was disposed of by allowing farmers to collect it daily and carry it away. Now an incinerator has been constructed and the refuse is burned. At each kitchen large galvanized cans are located into which the waste is emptied after being sorted into liquid, solid and tinware. At each garbage station there is a baited fly

trap of the Bishop type, in charge of which is a mess sergeant. The liquid is strained through several sieves into a hole in the ground, and any solid matter found together found together with that sorted originally, is burned in the incinerators. The tinware is crushed and burned and all the valuable materials are recovered.

Shortly after the camp was started garbage was dumped on the river side. Upon examination it was found to be heavily infested with living fly larvae.

Manure problem. The manure is sold to the farmers but responsibility for cleanliness in this method has not been fixed. In at least one instance farmers have not immediately plowed under or spread the material obtained and onehalf mile from the camp entrance heaps in a field were found heavily infested with fly larvae.

The manure is removed each day from the stable and placed in a wooden box at the entrance. These boxes are of a temporary nature, being built of wood and about a foot above the ground. Beneath these temporary boxes ideal conditions for breeding exist. It was suggested that permanent boxes od concrete be erected soon and that they be built directly upon the ground and have sloping bottoms.

The floors of the military stables are of hard dirt and are daily cleaned and then sprayed with a 10 to 12 per cent borax solution but the civilian stables have heavy plank floors and they promise to give unsatisfactory results owing to the fact that the flies could readily breed between the boards and under them.

Flea and louse problem. As yet no trouble in the camp has been caused by fleas or lice but the continual influx of troops makes this problem imminent. After some discussion as to methods of control, Major Lund gave his plan somewhat as follows: The infested company would be taken to the woods and sprayed

with gasoline, after which they would take a shower bath. The ground following this treatment would be burned over. The clothes were to be treated during this procedure with a dry heat of 60° C. or fumigated with sulphur dioxide.

June 3, 1918. Report 2.

Report of Visit to Camp Meade,Maryland.

W.D.Pierce.

On May 31,1918, at the invitation of Lieutenant A.H.Carhart and Sergt. Raymond Shannon, I spent the day at Camp Meade, Maryland. I was immediately introduced to Major G.L.Qualls, the camp surgeon, whose guest I became for the day. The sanitary work of the camp is entirely under the direction of Major Qualls who had several years experience on the Panama Canal. He has quite a corps of efficient surgeons and sanitarians assisting him and my judgment is that they are watching very vigilantly over the sanitation of the camp.

I was informed at the outset that the stables of one regiment were not in satisfactory condition but that they would soon be in shape. I also heard reports of poorly constructed sewer manholes which permitted fly breeding. I was shown a bad place at the waste disposal plant, where the contractor had dumped a lot of greese waste from the greese trap on the ground and blow flies were breeding abundantly. The old greese trap had been too small and a new one was constructed to take its place and this led to the dumping of the greese. Orders were immediately given for its treatment with a larvacide and its removal at the earliest possible moment. A corps of vigilant young men are constantly on the watch for such conditions and they are expected to get them remedied.

In general, the camp is on the plan I described in my second lecture- a large central parade ground area, bordered by headquarters and barracks and

margined by stables, with the hospital off at the side. Some 60,000 horses are quartered in the stables. This means that the utmost vigilance must be used to prevent fly breeding. The barn floors are dirt, a mixture of red and pipe clay hardened with oil, with the ground sloping to the entrance of the stall. The central aisle of each barn is high in the middle sloping to sides into which all stalls drain. The manure is daily swept out into the center aisle, loaded in the barn onto wagons and hauled to the railroad tracks where it is loaded on flat cars and packed tight for shipment to contractors who pay 20 cents per horse.per month. The stable yards are large and airy and the soil is somewhat sandy. These are daily scraped and the scrapings of sand straw and manure are hauled to a swamp which is being filled. The filled land is rapidly moving out into the swamp. As the manure is dumped a large fire is built over it, which burns down several inches, and then a layer of ashes is spread over this.

A sanitary sewage plant disposes of all human waste.

The garbage is daily gathered and carried to a large garbage disposal building, where the cans are emptied into wagons of a contractor, who pays 5 cents per man per month. This garbage is taken to a reducing plant in Baltimore. The cans are cleaned under high water pressure on rotary brushes and sterilized with crefinol, a product of the American Oil Disinfectant Co. This substance has a coefficient of 6. Wyandott's washing soda is also used in the cleaning. The grease is carried into a large pit or grease trap, and it was this trap which was giving trouble. Under the building there is a cement platform which is daily washed. The dirt at the edge of this was becoming rich enough for fly breeding and attention was being given to remedy this defect.

There are a number of swamps and spring filled lands in the camp. These are ditched and the ditches systematically oiled with a larvacide made up of 65 per cent water, 32 per cent crude oil, 3 per cent crefinol. Some of the clear water streams furnish typical Simulium and Tabanid breeding places. A scouting party under a lieutenant had just discovered a littl e stream breeding anopheles and the men were receiving instructions as to the detection of the larvae, pupae and egg masses. Sergeant Vickery informed me that the principal Anopheles is quadrimaculatus, while a few crucians and punctipennis occur. All water receptacles are periodically oiled. One bad place which was receiving attention was a hugh pile of waste metal, cans, etc., which was soon to be carted away.

Sergeant Shannon is experimenting successfully with fly baits and may have something to report later. The fly traps used are not as satisfactory as those used by Lieut.Gibson.

When recruits reach the camp they are stripped, examined and bathed and their clothing is sent to the sterilizing plant in the hospital enclosure. This building contains an American Sterilizer Co., (Erie,Pa.) disinfector No.1 which can stand 70 pounds steam, and which has a vacuum attachment and cyanide generator. It can give a 20 inch vacuum. The clothing is placed on a carriage which runs out on a track, and has four shelves. It receives a 60 pound steam disinfection for one hour.

Contrasting with Camp Humphreys. Borax is not used on the manure. There is no incinerator. The manure is not placed on boxes or anything else outside the barn, except occasionally and then the ground is subsequently treated with crefinol.

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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

June 3, 1918. 3:30 p.m.

The fourth session of the class held in the same room as before, was attended by the following: Barber,Basseches,Dusham,Gahan,Greene,Kotinsky, Middleton, Moles,Perrine,Pierce, St.George,Sanford,Sasscer,Smith,Snyder, Speare,Swartzell,Weigel,Whitcomb, and White, 20 in all.

Doctor Pierce opened the session by reading lecture No.3, entitled "Louse borne Diseases".

Mr.Snyder reported observing mosquito larvae in pot holes up the river.

Mr.Middleton reported complaints of mosquito bites from Ft.Myer,Va.

Doctor Pierce read his report on a day spent at Camp Meade,Md. This report is printed on pages 46 to 48 as Report No.2.

The session closed at 5 p.m.

Jacob Kotinsky,
Secretary.

Doctor Howard has called my attention to my erroneous statement on page 26 regarding Aedes argenteus in Hawaii. That statement should be crossed out in all copies. The confusion in my mind arose from the fact that I knew that one of the elements of yellow fever was lacking in Hawaii which made the opening of the Panama Canal somewhat dreaded there. This element, I now recall, was the fever and not the mosquito for its transmission.

J.K.

The dates of issue of pp.1-13, was May 22, 1918,; pp.14-24,May 27; pp. 25-48,June 6.

Supplement to Lecture 3. LOUSE BORNE DISEASES.
W.Dwight Pierce.

Lecture 3 was intended to include brief statements concerning each of the diseases mentioned, but time did not permit of their inclusion. The following summary will probably be of assistance in understanding the lecture.

Beri-beri - an East Indian and tropical disease characterized by weakness, anemia, dropsy,dyspnea (labored breathing) and paraplegia (paralysis of the legs); has been thought by many to be a nutritional disease caused by the absence of vitamines, especially in polished rice; other authorities lean toward the parasitic theory of origin, with possibly an insect vector.

Cerebrospinal meningitis,- inflammation of the membrane of the brain and spinal cord, causing paralysis, often fatal; common in the United States, and has caused many deaths in army camps; is largely transmitted through the mouth; caused by Diplococcus intra-cellularis meningitidis, and other organisms.

Conjunctivitis- inflammation of the conjunctiva of the eye.

Eczema- inflammation of the skin, with exudation of lymph.

Favus - a contagious parasitic disease of the hair follicles of the skin, with crusts, caused by Achorion schoenleini.

Five-day fever - an obscure new disease of the eastern front, transmitted by lice.

Folliculitis - inflammation of the hair follicles.

Gonorrhoea - a contagious inflammation with a purulent discharge from the genitals caused by the Gonococcus ; transmitted by contact and contamination of fingers.

Impetigo contagiosa- a contagious acute pustular inflammation of the skin.

Indian kala-azar - an epidemic fever of India and southern Asia, with recurring periods of fever, anemia, swollen abdomen and wasted body; caused by Leishmania donovani and transmitted usually by bed bugs.

Infective jaundice - an epidemic disease of the trenches characterized by a yellow coloration of the skin; readily transmitted through abrasions and through the mouth; caused by Spiroschaudinnia icterohaemorrhagiae.

Leprosy - an endemic, chronic, malignant disease with cutaneous and other lesions; mostly tropical, but present in small numbers in various parts of the United States; transmitted by contact; insects probably are often instrumental in transmission; caused by Bacillus leprae.

Melanodermia (Morbus errorum, vagabond's disease) - an aggravated condition due to continuous louse attack, resulting in hardened skin and pigmentation.

Pediculosis capitatis - the simple scalp dermatitis due to attack of Pediculus humanus; cosmopolitan.

Pediculosis corporis - the simple dermatitis due to attack of Pediculus corporis; cosmopolitan.

Pellagra - an endemic skin disease, originally of Italy, now common in Southern United States; thought by some to be a nutritional disease, and by others to be of parasitic or chemical origin, with the possibility of an insect vector.

Phlyctenular conjunctivitis - inflammation of the conjunctiva marked by the formation of ulcers.

Phlyctenular keratitis - inflammation of the cornea marked by the presence of papules or pustules.

Phthiriasis - The simple attack in the pubic region by Phthirus pubis.

Pityriasis - Scaly skin diseases caused by fungi of the genus Malassezia.

Plague - a contagious malignant epidemic disease of Asia, often spread over many parts of the world; usually transmitted by fleas; caused by Bacillus pestis.

Plica polonica - a verminous, scabby matting of the hair; frequent among the poorer Jews of Poland.

Porrigo - scald head, or favus of the head, due to the fungous Achorion schoenleini.

Poliomyelitis - (infantile paralysis) inflammation of the gray matter of the spinal cord; of uncertain origin, and uncertain transmission.

Prurigo senilis - a skin disease in which pustules are found.

Pustular dermatitis - a skin disease in which pustules are formed.

Relapsing fevers - Diseases with recurrent fevers, the European form occurring in Roumania and Russia; the Asiatic in South Asia; the North African in Algeria and Egypt; and the Tropical African forms in all parts of Tropical Africa; caused by species of Spirochaudinnia (Spirochaeta); transmitted by lice, bed bugs, fleas and ticks.

Septicaemia - a morbid condition caused by the absorption of septic products.

Smallpox - (variola) - a specific infectious disease with fever and papular eruption, followed by vesicles and pustules and the production of pits; the organism is not definitely isolated; transmitted by contact; common in temperate climates.

Trench fever - a disabling fever of the trenches in Europe; transmitted by lice only.

Tropical impetigo - a contagious inflammation of the skin also called pyosis mansoni; caused by Diplococcus pemphigi contagiosi.

Typhoid fever - a contagious intestinal disease; serious when it breaks out in army camps; cosmopolitan; transmitted by feces, contaminated food and water to the mouth; many kinds of insects may pollute the food; caused by Bacillus typhosus.

Typhus fever - an epidemic, contagious fever, with eruptions and great depression, but no lesion; a serious disease in Mexico and other parts of the tropics, and especially in the trenches in Europe, having caused the death of millions of people in Servia, Roumania, Russia, Germany, Austria and France; the organism is not definitely proven, but the louse is the only vector.

Urticaria - a rash or skin eruption with itching.

Volhynian fever - an obscure/new disease of the Volhynian region of the eastern front; transmitted by lice.

PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

BUREAU OF ENTOMOLOGY
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June 10, 1918. 3:45 p.m.

Met in Room 411, Bieber Building, with the following in attendance: Back, Barber, Boving, Caudell, Crawford, Dietz, Dusham, Gahan, Ginsburg, Greene, Hoffman, Hyslop, Kotinsky, Mann, Middleton, Moles, Morrison, Nelson, Perrine, Rana, Reed, Rohwer, Saint George, Sanford, Sasscer, Snyder, Speare, Swartzell, Weigel, White, thirty in all in addition to Dr. L.O. Howard and the leader.

The session was opened by an address by Doctor Howard on "The History of Medical Entomology in America". Under this title, Doctor Howard gave a general talk on the subject of the growth of the work in Medical Entomology in the United States. The communication was largely reminiscential and historical, and explanatory of the situation which has gradually developed into the condition, considered somewhat anomalous in certain quarters, by which a large number of men trained in medical entomology and a great mass of medical entomological information have centered around agricultural institutions such as the United States Department of Agriculture and the agricultural colleges.

The speaker, beginning with a statement concerning his own early medical education and medical affiliations combined with his entomological positions in the Department of Agriculture, showed that he was naturally led into such aspects of entomology as might have medical trend, and that the early work done on mosquitoes, house flies, fleas, and other insects of this nature naturally made the entomological organization of the U.S. Department of Agriculture one which possessed knowledge of great importance

and one which would naturally be appealed to when discoveries of the transmission of disease by insects began to be maddeby medical men.

The talk went from point to point in this gradual development, and was accompanied by anecdotes of experiences in the course of the work and with medical workers of prominence. It may be outlined as follows: Early experiments; correspondence mainly abstracted in Insect Life, 1888; Catskill Mountain experiment with kerosene and those which followed,1892-- ; Bulletin No.4, Division of Entomology--biology of Culex pipiens -- eggs of Anopheles,1896; full account of a generation of Anopheles, Scientific American 1900 -- illustrated lecture before the American Medical Association; Bulletin No.25 --Thayer and Lazear -- Reed and Carroll -- Sir Ronald Ross,1900 --; The Mosquito Book,1901 -- Texas lecture -- lecture at Boise, Idaho -- lecture before the Royal Society of Canada -- lecture before the Lowell Institute -- Lecturesat Yale and Cornell,1901-2; visit to Italy, 1902 -- Walter Reed's death; the Laredo outbreak of yellow fever in 1904 and the San Antonio situation in that year; work on the geographic distribution of the yellow fever mosquito and the influence of this work in the establishment of quarantine lines the following year; the New Orleans epidemic of 1905 -- visit to New Orleans in October of that year --Sir Rupert Boyce and Lord Mountmorres -- Dr.J.H.White, Dr.Quitman Kohnke, Dr.Rupert Blue, Dr.H.A.Veazie; the Vera Cruz working parties of the U.S.Public Health Service; Carnegie Monograph of the Mosquitoes of North and Central America and the West Indies (1905-1917); visit to Italy in 1910 -- Angelo Celli, B.Grassi, Tiraboschi; W.D.Hunter's address as retiring President of the Association of Economic Entomologists; the work of D.L.VanDine at Mound,La.; the work of W.V.King; house flies -- early bulletins -- work on the insect

fauna of human excrement (1900) -- magazine articles -- book on the house fly (1911); later work of the Bureau of Entomology -- pellagra, Rocky Mountain fever tick, Hutchison's work on house flies -- his present work on lice -- Pierce's bibliography of medical entomology and the class in medical entomology -- all of this latter work having been done under a definite section of the Bureau of Entomology established for the investigations of insects affecting the Health of man and animals; the present situation of the work and its possible future.

(The speaker did not mention the excellent American works, like Doane "Insects and Disease," Riley and Johannsen "Handbook of Medical Entomology", Herms "Medical and Veterinary Entomology", LePrince and Orenstein "Mosquito Control in Panama", and Chandler's just published "Animal Parasites and Human Disease", since these have been or will be brought before the class).

He also warned against further change of names of insects involved in medicine, citing the case of Aedes calopus, already changed from Stegomyia fasciata and now treated by Messrs Knab and Dyar as Aedes argenteus on possibly insufficient grounds. The name of an insect once entered more or less extensively in medical literature must not be changed, if the confidence and cooperation of the medical world is to be retained.

The address closed at 4:20.

Doctor Pierce urged the class to read Doctor Howard's Mosquito Book and also the economic portions of the first volume of the Mosquito Monograph by Howard, Dyar and Knab. These books unfortunately are not accessible to all.

Enlarged photographs of Pediculus corporis adult, nits on wool and freshly hatched larvae were passed around by the leader.

Dispersed at 4:40.

Jacob Kotinsky, Secretary.

June 17, 1918.

Lecture 5. THE LIFE HISTORY OF THE HUMAN LOUSE.

W. Dwight Pierce.

In the third lecture you were given a very brief and concise statement of the claims made as to the transmission of disease by lice, with a number of suggestions for future work along certain lines. It is often the case that we can obtain important clues for further research by taking time to sift over the work of other investigators and carefully analyze their methods and results. It is with this in mind that I have been directing my researches in the annals of medical entomology. Heretofore it has been a science of individual effort, and a tremendous amount of building material has been quarried out. Let us now assemble these materials, build a firm foundation of science of the Entomology of Disease, Hygiene and Sanitation, and upon that foundation erect a structure of coordinated and systematic research.

It will take us some weeks and months to sift out the building materials and test their strength. In a few cases we have had this sifting done for us, and one of the cases is the Louse.

Until the outbreak of the great war there had been a great mass of desultory writing upon the three species of human lice but this was in all languages and few had made any attempt to classify and arrange the knowledge thus obtained. Since the beginning of the war however the louse has been a major problem and there have been more titles published on it than on any other disease carrying insect. The first comprehensive work was published by DeHase (1915-1916) in a series of papers, part of which are inaccessible because of the difficulty of getting literature from

Germany. This has now been followed by two excellent monographs by Prof. Nuttall (1917), the second of which gives a complete bibliography of the literature of human lice, a summary of the evidence of disease transmission, and extensive biological studies. With the large number of students now concentrating attention on these vermin we may expect that our literature will be greatly enriched with many more fine contributions.

The human lice have generally been regarded as belonging to three different species, Pediculus humanus Linnaeus (capitis DeGeer), P. corporis DeGeer (vestimenti Nitzsch), and Phthirus pubis Linnaeus (inguinalis Redi). Nuttall as well as Bacot and others have recently come to the conclusion that the head louse and body louse are merely races of one species, and hence Nuttall united them under P. humanis for convenience, designating the head louse as capitis and the body louse as corporis. Other writers are not wholly convinced in regard to the union of the two species and we shall await further studies with interest.

The true P. humanus, or head louse, is usually confined to the head, mostly about the occiput and ears, but it may spread over the body, establish itself on other hairy parts, and may be confined to the pubic hairs and multiply there. The body louse P. corporis lives usually on the body and in the clothing and is very rarely found on the head. The pubic louse, Phthirus pubis is usually found on the hairs in the pubic region but may occur in other hairy parts of the body.

The body and head lice are found on all races of men and seem to show some varietal differences according to the host, but the pubic louse occurs only on the Caucasian race. None of these species occurs on any other host than man, although a closely related species Pediculus consobrinus Piaget

occurs on a monkey (Ateles pentadactylus).

The collections of the National Museum are woefully lacking in material of all these species. I therefore take the occasion to request specimens from all correspondents who may have occasion to get them. The material should be in all stages, in alcohol, and should give locality, date, sex and race of man on whom collected.

Children and old people are much more likely to be affected with head lice than active men and women, and girls because of their long hair are much more frequently infested than boys. On the other hand men seem to be more often the subjects of attack by corporis and pubis.

Bacot carried out hybridizing experiments with humanus (capitis) and corporis, carrying the offspring to the third generation. It is on the strength of such studies that Nuttall united the two under the name humanus.

There is considerable variation in the number of individuals in the sexes. The males are smaller than the females.

The eggs are elongate, oboval, with a granulated cap or operculum at the outer end. They are cemented singly to a hair (in all three species), or a thread (P.corporis). Occasionally a single hair will be covered with them. Oviposition usually commences in P. corprois in from 2 to 5 days after hatching.

When a female is ready to oviposit she clings to a hair or thread, and slipping backward grasps it also with the gonopods and the posterior lobes of the last segment. A drop of cement is excreted followed by the egg, which is thus firmly cemented to the hair and the insect moves away. The entire operation consumes about 17 seconds. The operculum is usually directed away from the root of the hair.

Oviposition takes place most readily at about 30° C.(86°F.) and ceases at 20° C. (68° F.). They lay rapidly at 37° C. (99°F.) although this temperature shortens their lives. Infected persons who remove their clothing at night consequently become less heavily infested than those who wear their clothing continuously. The periodic cooling of the clothing and the lice therein leads to their progeny being materially reduced.

Nuttall shows that previous authors have found the total number of eggs laid by a female corporis ranged from 55 to 295, and of humanis (capitis) 50 to 141. In his own experiments he obtained results warranting his conclusion that under optimum natural conditions a female corporis lays 275-300 eggs, at the rate of 9-12 per day, averaging 9.7 per day, for 20 or 30 days.

Nuttall and Bacot are both agreed that capitis prefers to lay its eggs on hairs, but they do not agree as to whether corporis prefers cloth to hairs for oviposition.

There is no evidence of parthenogenesis.

The length of the egg period varies from 4 to 16 days under normal conditions and may be retarded to the 35th day or possibly later by cold periods. Apparently 30° C.(86°F.) gives about the optimum condition for hatching, although the shortest period experienced was at 37 to 38°C. (99-101°F.). The effective zone for the eggs stage is from slightly under 20 to 40°C. (68-108°F.). In this connection Nuttall has made some very unfortunate remarks. He discredits the 7 day record with 3 individuals at 20°C. made by Widmann, the 10 to 12 day records at the same temperature made by Heymann, and Legroux' statement that they rarely hatch at 16-18°C., because Sikora and Hase recorded failures at 20° and Nuttall and Hindle failed to hatch eggs at 22°C.

It is quite possible at 20°C. and one humidity to obtain death, at another humidity 12 day development, at another 7 day development, and at still a different humidity possibly a very long developmental period. All of Nuttall's remarks on temperature effects must be more or less discounted because of his ignoring the important humidity factor. In fact he states that there is no evidence that eggs maintained at 22°C. or under are capable of hatching, but he quotes quite a series of retarded development records in which the eggs were maintained for more or less long periods at low temperatures. For instance, Widman kept eggs for 24 hours at -10°C., and then transferred them to 26-30°C., and they hatched in 17 days. After keeping eggs at 9°C. for two or three weeks, Heymann transferred them to a favorable temperature and they developed in 15 days. The length of time the eggs can stand a given low temperature will depend to a large measure on the humidity.At a given temperature it appeared that dryness may retard development two or three days or more.

There are three larval stages, or possibly we may call the last the nymphal stage. The larvae such blood from their human host. The first molt occurs on the 3rd to 8½h day, and the other stages are correspondingly long.

In molting the skin splits longitudinally from base to apex of thorax and along the base of the head to near the base of the palps.

The entire life cycle on the human body, of corporis may be as short as 16 days, 8 for the egg, 2 for the first and second larval stages, 3 for the third stage, and 1 day preovipositional period. The head louse has been carried through its entire life cycle in 17 days.

The lice cannot live long without food unless at uneffective tempera[illegible],

the longest period recorded being 10 days at 5°C (41°F.). The longest record of fed adults is 46 days for a female recorded by Bacot. One male lived 32 days and fertilized eighteen females.

The frequency with which lice feed is dependent upon the rate of digestion, which is dependent upon climatic conditions. They feed more frequently at body temperatures than when kept cool. They feed at all times of the day. Lice which have not had a feed for some time become ravenous and often feed to excess, rupturing the intestines and causing death.

The lice seem to avoid light except when hungry. They seem to be quite sensitive to excessive warmth and will leave a fever patient.

In the absence of definite humidity data we may roughly describe the zones of climatic influence on the lice as follows: The zone of minimum fatal temperatures for eggs is below 20°C. (68°F.) and for adults lies below zero centigrade (32° F.). The zone of dormancy in adults extends from about -10° to 5°C.(14° to 41°F.). The zone of sluggish movement without reproductive activity and with practically no digestive processes extends from 5° to 20°C. (41 -68°F.). Digestion ceases at 12°C. The zone of optimum activity lies between 20° and 40°C. (68 -104°F.) with the optimum about 30°C. Practically all egg hatching occurs within this zone, as does all oviposition, practically all assimilation of food, and all normal activity. From 40 to 44°C. the lice are wildly active, this zone represents one of exhaustion in which death of eggs occurs. Above 44°C. (112°F.) lies the zone of maximum fatal temperatures. In control work 50°C. (122°F) for one-half hour is sufficient to kill all stages, and 60°C.(140°F.) for one-quarter of an hour gives a very thorough control.

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Lecture 5. THE BIOLOGY OF LICE IN ITS RELATION TO CONTROL MEASURES.

Robert H. Hutchison.

From information I have obtained, directly or indirectly, from medical men in the army, it appears that the louse problem is not very acute in the camps in this country as yet. A few cases appeared in Camp Dix,N.J. last winter. Some cases are said to occur in camps on the Mexican border, and I am told that troops which are sent out for target practice on artillery or rifle ranges for weeks at a time often show well developed cases upon their return to permanent camps. In the permanent camps however the sanitary arrangements seem to be such as to discourage their introduction. Among our troops in France conditions are doubtless similar to those obtaining in the other armies under similar surroundings. A fairly clear idea of what they have to contend with "over there"over there" can be gathered from reading articles by Peacock,Kinloch and Bacot.

In the civilian population of this country there are indications of important changes in the general problem. In times of peace the louse problem is most acute in jails, poor houses and like institutions; among vagrants and the extremely poor classes; among gangs of laborers, as in construction camps, lumber camps, threshing gangs,etc., and among immigrants. Since our entrance into the war there have been economic changes which have shifted some of these centers of infestation. For example, there are many more camps of laborers engaged in temporary construction work, and Mr. Wood's report indicates that lice are giving considerable trouble there. There is probably an increase in the size and number of lumber camps. On the other hand I have been informed by the captain in charge of the House of Detention at New Orleans that the vagrant population, which has always

been their worst source of information, has been reduced more than two-thirds. It is also well known that immigration has been greatly reduced.

The urgency of the problem in the armies has led to extensive investigations of control measures and of the biology of lice. The knowledge of the biology of the body louse was surprisingly meager up to the time the war began. It is my purpose in this paper to call attention to several important additions to the knowledge of biology of lice and to point out their relation to practical control work, for without a knowledge of these points one cannot expect to intelligently interpret the results of control work. These additions to our knowledge of biology are due in no small measure to the improved technique for rearing lice as evolved by Bacot, Sikora and Nuttall. Warburton's method of placing the insects on cloth in plugged tubes, feeding them twice daily and placing the tube in the pocket or incubator between feeds has been largely followed with modifications by other workers, but after many attempts at rearing lice under more normal conditions and providing them with unlimited opportunities for feeding, Nuttall finally worked out the two methods which he describes under the names of the "felt cell method" and the "wristlet method". For the details of these methods it is best to consult the original description in Nuttall's article on the Biology of Pediculus humanus. In fact I have avoided giving a stereotyped account of the life history, on the assumption that his article will be read by all those interested.

The first point to be noted is the fact that body lice may occur on the body as well as on the clothing. Nuttall has brought out convincing evidence that nits as well as lice themselves are often found upon the body hairs, especially in the axillae, the hairs of the breast, and at times on the pubic hairs and even the hairs of the thigh and leg. I have seen two

cases in which both lice and nits were present in the axillae. The importance of this point as regards control measures is obvious. Disinfection of the clothing is not sufficient, but must be accompanied by a thorough bath with some insecticidal liquid, such as cresol-soap or Grub's gasoline emulsion formula, or the kerosene soap used by Boyd in his work with the Mexican laborers of the Sante Fe Railroad.

Moreover it was soon discovered from actual experience in this war that a disinsection of a part of the clothing was entirely ineffective; for example, if clean shirts are provided, while the trousers have not been cleaned, lice quickly migrate from the trousers to the clean shirt which affords them new areas for deposition. Thus conditions are soon as bad as before.

A second point having an important bearing on control measures is the number of eggs laid per female and their rate of development. The importance of the improved technique for rearing lice, mentioned above, consists in showing that previous statements regarding the number of eggs laid clearly underestimated their power of reproduction. When the lice are fed but twice a day only four to five or six eggs are obtained per day, while by the wristlet method Nuttall obtained as high as twelve eggs per day per female, the average being about ten. He states that corporis may lay 275 to 300 eggs during its lifetime. By the same method I have obtained as high as fourteen eggs per day with an average of about twelve per day during a period of two weeks.

Old statements as to the length of the incubation period of the eggs are also erroneous. Instead of the 3 to 4 day period so often given, it is found that at temperatures of 40 to 45°C., the embryo dies without emerging; at 37°C. hatching occurs in four to eight days; in my experience they hatch in six to seven days at temperature of 33 to 34°C. and in eight days at 30°C.

Nuttall shows that at 25°C. development is slow, lasting sixteen days while they fail to hatch at temperatures below 22°C. In testing various insecticides for their effect on the eggs, it is therefore necessary to provide the proper temperature conditions; otherwise failure to hatch may be due to low temperature rather than to the chemical or other agent tested. There is still work to be done on the effect of humidity on the incubation period.

In interpreting results from control experiments it is important to bear in mind that lice will lay infertile eggs. Isolated females to which males have not had access, will lay eggs at about the normal rate. Such eggs are all sterile and show no development. There is no evidence of any parthenogenesis. But even females to which males have had access will lay some infertile eggs especially near the beginning and end of their lives. Nuttall says, that at constant temperature of 30°C. we may expect roundly 70 per cent of a given lot of eggs to hatch. Of those which fail to hatch some are fertile, some undergo partial development but for some unexplained reason fail to complete development. He points out that "hatching along is not therefore a true test of fertility", and it follows that it is also not a direct test of the efficiency of control measures. For accurate work on the effect of a given chemical, eggs of known age should be used, preferably after they have reached the stage when the eyes appear as faint brown spots on each side of the head of the embryo. By examination with the binocular before treatment, the presence of these eye spots will indicate the number which are fertile and their absence, the number sterile. Having determined the proportion of infertile eggs, the treated eggs must be checked by controls in order to determine the

number of fertile eggs which for some reason may fail to complete development.

The freshly laid egg is almost transparent, but as the embryo develops the egg assumes a yellowish color and the eyes first appear as pinkish spots gradually turning red or brown in color, finally becoming black. After the limbs become clearly defined and the claws and eyes darken, there are slight movements of the limbs, and of particles within the body of the embryo, and periodic pumping movements of the pharynx begin to appear. These pumping movements become more frequent as time for emergence approaches. Sikora and Nuttall were the first to grasp the meaning of these pumping movements and show that they are intimately concerned with the act of emergence. When the larva is ready to emerge, the air is pumped in rapidly through the socalled air canals of the operculum. The air is accumulated in the anterior end of the shell, the body of the embryo completely filling the remainder. As pumping continues the air is passed on through the gut "the bubbles being distinctly seen through the transparent glassy shell as they pass backward" and are expelled through the anus and accumulate in the posterior end, thus pushing the embryo up against the operculum. "This pressure of the air cushion finally overcomes the resistance of the operculum and the latter springs open". The head of the larva is thus forced out and assumes a normal position. Soon the first pair of legs is withdrawn. These are quickly brought into action and with their aid the remainder of the body is soon withdrawn. This highly interesting process is important in its relation to control measures. In the first place if oily or greasy substances are used they occlude the air canals of the operculum and the larva dies. Some substances when applied to young eggs, may evaporate without acting directly

on the embryo and leave the air canals open by the time the embryo has reached the stage of pumping movements. In my control experiments I have obtained results which indicate this, the mature eggs being destroyed and the younger eggs emerging some days later showing that the chemical has not affected the contents of the egg but killed the older eggs by occlusion of the air canals, and passed off in time to permit the younger ones to hatch.

In the second place the movements within the mature eggs afford a fairly reliable means of determining quickly but roughly whether the given chemical has been effective. Without waiting a week or more to determine whether the eggs will hatch it is often possible by examination under the binocular to determine whether all movement has ceased. However, if there is any question of the chemical passing off quickly by evaporation it would be necessary to await the normal period of development to determine whether the younger eggs will emerge.

A third point of importance is that proper temperature conditions must be provided in such experiments, to permit normal emergence as well as normal incubation. If the temperatures are too low the process of emergence is slow and the vitelline membrane will dry before the larva has freed itself. As a result the larva dies with the head and first pair of legs and part of the thorax outside the shell, but the posterior end of the body and the second and third pairs of legs stuck to the dried membrane , or it may be that the larva will die without bursting the membrane. In some cases I have found larvae with all but one leg free from the membrane but this so firmly stuck fast as to prevent escape. It is important therefore to bear in mind that the effect of low temperatures may entirely outweigh the effect of the control measure under trial. Effective temperature

is higher than for most other insects.

The egg shell is very tough and resistant to chemicals as is also the cement by which it is fastened and there is no known way of removing them without first destroying the fibers or hair to which they are attached. Hase describes how the Russian prisoners tried to reduce ~~xkxxx~~ infestation by hanging shirts on a wire and beating with sticks, and Legendre recommends vigorous brushing with a stiff brush. Hase is doubtless correct in pointing out that beating fails to dislodge many of the lice or to crush any of the eggs and that brushing may tear loose some fibers with attached eggs but actually destroys very few. On the contrary it is pointed out that this may be the means of spreading the infestation to other men rather than affecting any reduction. Hase carried out experiments showing that lice can crawl up to the surface after burial in several inches of dry sand or earth. If shaken or beaten out of the clothing to the ground and pressed into the sand under the heel they will crawl to the surface and attach to the first host near them, which they have abundant opportunity to do in a crowded prison camp, especially when the weather permits the prisoners to lie down on the ground. Eggs brushed from clothing will hatch if temperatures are favorable, and the issuing larvae reach new hosts in the same way.

Many experiments have been carried out by Hase and Nuttall with a view to determining what kind of materials lice prefer for oviposition. They agree in showing that rough materials such as felt,wool and flannel are preferred. However, in case of necessity the lice can and will oviposit on smooth materials such as silk and sateen. It has been suggested that infestation could be greatly reduced and even remedied entirely by wearing for 1 to 24 hours a broad band of felt or rough wool under the

clothes, with the idea that lice would collect on this and they and their eggs could then be destroyed by burning. But the preference of lice for such material and the difference between this and the uniform is not marked enough to make it really effective. However, it is a convenient way of obtaining lice and, more especially, eggs of known age for experimental purposes.

In practical control work the question is likely to arise as to how long discarded but untreated clothing will remain infective. The answer to this, of course, depends on how long lice can live without food and how long it takes for all the eggs to hatch. Experiments show that lice can live without food from 2 - 3 days at 35°C., 3 days at 30°C., 3-5 days at 22°C., and about 7 days at 10°C. Occasional records of 9 or 10 days at low temperatures have been published.

As stated above, eggs will hatch in 16 days at 25°C., but below 22°C. they usually do not hatch. How long a period of low temperatures they can endure, and still hatch when the temperature is again raised is not known beyond a statement by Nuttall that he delayed hatching to 35 days by low temperatures. Certainly the safest plan would be to allow 30 to 40 days of cool weather or two weeks of hot weather for all the eggs in discarded clothing to hatch.

There are several other phases of the biology of lice which could be mentioned if time permitted. For example, the locomotory powers would repay study. Their inability to make any headway on smooth metal or glass when inclined at an angle of more than 2 to 3°, and their inability to crawl on smooth vertical surfaces such as rubber gloves or boots, as contrasted with their gymnastic skill on threads or fibrous materials and their power of clinging to anything which they can clasp with their claws explain the

different protective uniforms worn by those who have had to do with typhus epidemics.

Their different reactions to light when fully fed or when hungry has a bearing on the question as to how they find new hosts.

There are yet many phases of the biology which need elucidation. For example, the question as to the state of development of the olfactory sense and whether this comes into use in finding a new host. Hase concludes that they have a fairly keen olfactory sense because they are quickly repelled by substances like tar and etherial oils. According to him, they recognize and avoid the odor of horses, - the clothing of those artillery men who drive and care for the horses is saturated with the horse odor and free from lice, while others in the same battery without the horse odor are infested. On the other hand, a hungry louse placed on a glass slide near a freshly drawn drop of blood is apparently entirely unaware of the proximity of food. Likewise a hungry louse on a piece of cloth is apparently unaware of the presence of a human hand a chance to feed until a finger has been pushed within one-half inch or less of it, and that may be a positive reaction to the heat radiated from the hand rather than an odor reaction.

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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

June 17, 1918. 3:30 p.m.

The sixth session of the class was held in room 411 Bieber Building, in the presence of the following: Barber, Böving, Dusham, Gahan, Hoffman, Hyslop, Kneale, Kotinsky, Morrison, Perrine, Reed, St.George, Sanford, Snyder, Speare, Swartzell, White and the leader, 18 in all.

On motion of the secretary the class unanimously voted hearty thanks to Dr.L.O.Howard for the instructive lecture given us the previous week. It was also agreed, Doctor Howard consenting, to hold an evening session during the course to enable us to hear Doctor Howard's "History of Medical Entomology in America" in full.

The secretary advised the class of the numerous requests for our Proceedings received from entomologists in many states, as a result of the note published in the Emergency Circular. Evidently the entomological world is seriously regarding the importance of our undertaking and is flocking to prepare for possible service.

Messrs. Kotinsky and Pierce spoke of the abominable fly situation at Center Market in Washington.

The leader read a number of notices which follow and then read his lecture on "The Life History of the Human Louse", and Mr. Hutchison's paper on "The Biology of Lice in its relation to control measures".

Jacob Kotinsky,

Secretary.

NOTICES TO THE CLASS.

On account of the great amount of clerical work involved in a class with over a hundred correspondents, your letters will not be acknowledged unless they contain questions. Occasionally it will be impossible to send the proceedings regularly. If you find a number has been skipped, please notify the secretary.

As many of you are traveling it is realized that you cannot be regular in sending in your answers and statements. These will be credited to you when received. Please endeavor to follow the course for your own benefit. The assignments will include mental drills, research questions, problems and reports. The proceedings of the class will include lectures, reports, tabulations, bibliographies, summaries of reports etc. We are conforming to circumstances, and necessarily not always logical in the order of events.

If at the end of the course the class votes that the proceedings be printed and sold at cost after rearrangement and possible elaboration, this will be done. In view of such a possible contingency, original photographs and illustrations may be contributed as your share of the proceedings with full credit. This is a cooperative class and will become more valuable to all of us in proportion as the whole class contributes to the subject.

In general the course from now on will cover the following subjects:

Non biting flies - biting flies - at least 5 lectures.
Mosquitoes - at least 2 lectures.
Fleas - 2 lectures.
Cockroaches.
Ticks
Myiases and dermatoses - 2 lectures.
Miscellaneous insect borne diseases.
Insect poisoning.
Stored food insects.
Protozoal diseases borne by insects.

Bacterial diseases borne by insects.
Worm diseases " " "
Fumigation.
Camp - household -city - rural sanitation-4 lectures at least.

Thirty-five lectures will be included in the course and they will be contributed by a number of men, experts on certain subjects.

GENERAL ASSIGNMENT.

As we know very little of the entomological sanitation in the country I wish to make the following general assignment:

Please report on your town or section of city at your earliest convenience the following matters, and also endeavor, where possible in your travels this year to report on towns and camps and extra cantonmental sites in the same manner. We will then tabulate and report back to the class the findings with suggested action.

Are flies abundant around city markets, groceries, meat markets, and other food distribution points, and have they access directly to the food? Report specifically on the markets found in bad condition and the flies present if identified.

Are other insects found commonly in food or at food in markets or places where food is served?

What measures are taken to reduce flies around places where food is sold or served?

Are there any municipal regulations bearing on insects? Are they enforced? Send copies if available.

How is stable manure handled? Is it left standing around the stables?

Are mosquitoes breeding within the town limits?

What measures are taken against mosquito breeding?

Are there any insect borne diseases in your town?

If so, please watch their progress and report. If you have time discover the source.

Are there complaints of bedbugs, fleas, lice, ants, cockroaches, etc.?

How is garbage handled? Is it exposed to flies? How often removed? Is it removed by city, contractor, or individual arrangement?

Note any other bloodsucking insects prevalent on man or animals.

Have you personally called attention of officials to any of these conditions?

By investigating these questions you will become personally acquainted with the problems of an entomological sanitarian. You should look at each case as a problem to be solved and work out a way to solve it. If the problem is particularly severe it may require further investigation.

It should be borne in mind that you are not to let official duties be interfered with, but most of these observations can be made as you go back and forth.

W.Dwight Pierce,
Class Leader.

Lecture 6. THE CONTROL OF LICE.

W.Dwight Pierce.

The Control of Human Lice.

Never in the history of the world has the subject of insect borne diseases become so prominent as it has since the discovery that several of the great diseases which ravage nations and armies are borne by lice and that personal prophylaxis alone will combat these diseases.

Had the scientists not known how typhus fever was spread the entire nation of Serbia and possibly most of the peoples of eastern Europe and the poor peoples of all the war stricken nations as well as the men in the trenches might have been wiped out by now. As a matter of fact probably one-third of the Serbian nation was lost and hundreds of thousands of Roumanians, Austrians, Russians, Germans and Turks before the medical authorities obtained the necessary grip on the situation. The lice would have gone on disabling the men in western trenches with trench fever if they had not been proven to be the vectors.

The knowledge of the means of conveyance of a disease is the first requisite toward the successful combatting of that disease.

I cannot lay too much stress on the importance of controlling the lice in the armies in Europe, nor on the still greater importance of preventing their becoming established in the cantonments in this country. Because they are not present now is by no means an indication that they may not be soon. Let us hope that every camp in America is equipped with adequate facilities to prevent lice from gaining a foothold.

In this lecture I shall attempt to summarize the vast amount of

literature accumulated since the beginning of the war, on louse control. If nothing else can impress on your minds the importance of the question surely the heroic means taken to combat the pest should do that.

The ravages of lice. The eastern theatre of war has long been scourged with louse borne epidemics. During the Crimean war the British troops became seriously infested becoming anaemiated and debilitated and death carried off many of them. The only remedy available was to put the wet flannels in the snow for two days - this killing all but the nits.(Shipley, A.E., Brit.Med.Journ.No.2807,p.679.

Typhus fever ravaged the Bulgarian troops during the two Balkan wars to such an extent that it was estimated by a staff officer that they lost more soldiers in a short period of time from fleck typhus than from all other diseases combined.

During the present war the lice at first were most serious in the Eastern theatre, probably due to the greater congestion of population among the Slavic peoples. The Germans first had to combat them among the Russian prisoners, finding the French almost completely free. But by mixing the prisoners and the exchange among them of souvenirs, especially shoulder straps, under which the lice clung in masses, the lice became generally distributed. It was not long before the German armies found the louse a very live problem and their scientific journals are full of papers on the control of the vermin.

In Serbia a few cases of typhus fever occurred in October 1914, and in January 1915 the disease was epidemic among Austrian prisoners who were greatly crowded and necessarily compelled to live under very insanitary conditions. The disease quickly spread from them to other individuals and

as there was no quarantine and the Austrian prisoners and infected individuals were sent or allowed to go to various parts of the country, Serbia was soon afflicted with a terrible and widespread epidemic. Weakened by the ravages of war, the country was not prepared for an epidemic and for a time typhus raged almost at will. The majority of the Serbian doctors, who were small in number became afflicted. The epidemic was at its height in April when the number of cases was at least 9000 a day, but it was impossible to gauge the number of cases in the rural districts. At least 100,000 men or a quarter of the army were destroyed in this epidemic which was brought to a stop by the energetic efforts of Dr.R.P. Strong and his American assistants. The work of the Serbian Sanitary Commission under Doctor Strong is briefly detailed in the following publications: Strong, R.P.,1915, Boston Med.&Surg.Journ.,vol.173,No.7,pp.359-262; Strong R.P., 1915, Med.Rec.Nov.20,p.892.

In Roumania typhus fever and relapsing fever became epidemic in the winter of 1916-17 and the conditions which occurred there are very vividly protrayed by Wells and Perkins (Wells H.G., and Perkins, R.G. 1918, Journ. Amer.Med.Assn., vol.70,No.11,pp.743-753).

It was inevitable that the louse should reach the western trenches and contaminate them with disease, and we find that now trench fever especially is considered the most disabling disease of the western trenches. Reports show that a very high percentage of the men in the trenches become verminous.

Treatment in general: Out of such conditions have arisen heroic methods of treatment. When things are done in armies they must be done on a large scale. Consequently we find that Doctor Strong's commission undertook to bathe and cleanse the wearing apparel of the Serbian nation, and

that similar efforts were made in Roumania. And furthermore with the cleansing came the extermination of the epidemics.

The British in 1915 began isolating German prisoners for 14 days after capture for observation, and they treated or destroyed their clothing and bathed them as promptly as possible. The isolation of prisoners is practiced quite generally.

It has become a well defined principle now that new acquisitions to a military camp must be treated for lice. This treatment is called delousing or disinsection. When returning from the trenches, prisoners of war, men who have been on furlough, new recruits, and new units must be inspected and given a complete delousing treatment on general principles. This treatment often varies in detail but consists of thorough bathing, cleansing of the clothes and accoutrements, and disinfection of bedding and baggage.

On the Mexican border the United States Public Health Service have found it necessary to exercise a rigid supervision over refugees from Mexico, as the disturbed political conditions in that country have resulted in a spreading of typhus fever from the plateau regions where it is endemic to all parts of the country. The immigrants are stripped and given identification tags for their clothing and baggage, and then they themselves are given thorough spraying with gasoline emulsion, and then baths with warm water and if lice are present the hair of the men and boys is clipped and burned. The women have a mixture of equal parts of kerosene and acetic acid applied to the hair for half an hour with a towel covering the head. The acetic acid loosens the eggs from the hair and the kerosene kills or stupefies the lice. Before entering the bath liquid soap is sprayed on each person. The soap is made by boiling one part of

soap chips in four parts of water and then adding two parts of kerosene oil, or four parts of gasoline. This jellies when cold, and one part of this soap jelly is added to four parts of warm water, making a good liquid soap at very small cost. The clothing is disinfected by being placed in bundles in the steam chamber in which a vacuum of 10 to 15 inches is created and live steam is then introduced until the gauge shows 20 pounds, which gives a temperature of 259°F. This is maintained for 10 minutes to insure penetration. The creation of a second vacuum of 10 inches and holding it for 10 minutes will dry the clothing completely. (Pierce C.C.,1917, U.S.Public Health Repts., vol.32,no.13, pp.426-429).

Bath outfits. Early in the war it became apparent that portable clothing and disinsecting apparatus must be developed. In Russia, Brink (Voyenno Med.J.,Petrograd,1915,vol.264,med.-spec.pt.,pp.440-449) late in November 1914, devised a portable traveling bath capable of bathing a regiment of 4000 to 4500 men in 1½ to 2 days.

Many modifications of this have been devised but we may give in general a composite of these, which may serve as the model.

The outfit may consist of a wagon train with tents or portable huts, or a train, or at halting stations may consist of permanent structures. The portable wagon drawn outfit can most nearly approach the trenches and is considered the best by Brink. The equipment should be capable of washing and cleaning the clothing and equipment of at least 100 men an hour and to discharge each man in about half an hour, thus making it possible to wash an army unit in the course of a short time.

There is also supposed to be a distinct separation between unclean and clean, and the cleaned men must not mix with the uncleaned.

Disrobing. The men come into the receiving tent, car or room and undress, receiving numbered tags for identification of their belongings. In the disrobing room each man places his clothing in a bag, his accoutrements in another receptacle, personal belongings which do not need fumigation in still another, all of these receptacles bearing the number given to him.

Bath. They proceed into the bath room and receive either shower or tub bath, and in some cases pass through several baths. In the Russian portable outfits the bath equipment consists of folding benches, zinc covered tubs, wash basins; spoon measures for liquid soap, sacks for sterilization of clothes, little numbered tags, canvass folding tanks for water, kerosene lamps to be used at night, a barber shop. Naphtha soap was used as the cleaning agent. On the Mexican border at El Paso the men are first sprayed with gasoline soap and then walk through a continuous spray in a tank of water about a foot deep. On the Santa Fé Railroad according to Boyd (Am.Journ.Pub.Health,vol.7,no.8,pp.667,671) the Mexicans are given a 10 minute bath in kerosene and soap suds (equal parts), with a kerosene and vinegar bath for the hair.

In at least one of the baths hot water should be used. The liquid soap described above applied as a spray is a very good method and prevents contamination by means of the soap.

On leaving the bath room they enter the barber shop where the hair is clipped. Bags should be tied around the neck to catch the hair, which is burned. The men may also be shaved.

They then pass into the dressing room where they receive clean underclothes and their outer garments and other possessions disinfected and disinsected.

Clothing. Meanwhile the clothing has undergone one of several types of treatment such as heat, steam, gas, or washing in insecticides.

Exposure to a dry heat of 60°C. (140°F.) or higher for 30 minutes will kill the lice and all nits in the clothing, in fact a 15 minute exposure at 60°C. or 30 minutes at 55°C. is satisfactory. The heating is often done in temporary huts near the front. In Russia and Roumania the huts were often made of sod. As they are often hastily extemporized, it is desirable to have a satisfactory means of determining whether sufficient heat has been applied to obtain the desired results. Bacot (Brit.Med.Journ. No.2953,Aug.4,1917,p.151) suggests placing in porcelain dishes 2½ inches deep by 2½ inches in diameter, 7 grams of stearin (trade melting point 60°C), which requires 30 minutes to melt at ~~at~~ 60°C.(140°F.). Thus it can easily be determined whether sufficient heat has been applied for a sufficient time. The dishes should be placed slightly lower than the level of the lowest garments in the sterilizing room.

Bacot also suggests (Brit.Med.Journ.No.2931,Mar.3,1917,pp.296-297) the use of a tubular oven with traveling hangers so that the clothing could be taken out in rotation.

Soaking in hot water at 55°C. for 30 minutes gives complete control according to Bacot, but this method takes longer because of the necessity of drying the clothing afterward.

Exposure of clothes in sacks to steam at a temperature of 90-95°C. (199-203°F.) for 20 minutes is entirely satisfactory according to Gurevich (Voyenno-Med.Journ.vol,245,1916,pp.323-327).

Vacuum fumigation has received several very successful trials. On the Mexican border it has been used by the Public Health Service, where a hydrocyanic acid gas fumigation is used. With closed chests, trunks, etc.,

a vacuum of 20 inches and a 30 minute exposure to the gas from 4 pounds of sodium cyanide per 100 cubic feet is necessary, but with clothes hung loosely in the chamber the vacuum may be reduced to 15 inches and the cyanide to 3 ounces.

The German State Railways, early in the war found it necessary to fumigate railway carriages which had transported Russian prisoners, because these cars were especially badly infested. A large iron cylinder was constructed, into which a railway carriage could be run. The cylinder was hermetically sealed, the air exhausted, and the contents warmed by steam pipes. The lice in the upholstery of the cars can survive exposures to partial vacuum but the heat kills them.

Vacuum fumigation is also described, using 12 per cent formaldehyde and water vapor for three quarters of an hour. At Camp Meade a steam cylinder sterilizer with vacuum and cyanide fumigation attachments is installed for general disinfection and disinsection purposes.

Under temporary conditions neither hot air, steam nor vacuum can be used to cleanse the garments and in such cases hot water washing or the use of other expedients is necessary. The outer clothing should be ironed and brushed at least once a week. Garments may be freed of lice by immersion in a petrol or benzine bath. If a bath and extractor such as are employed in dry cleaning establishments are used there is less danger from fire and about 90 per cent of the liquid is recovered for further use. Such a bath is necessary for uniforms and woolen garments generally.

A great number of remedies have been suggested and tried, but from these we may select a few which appear to be especially good. There probably will be times when one or another will be more practicable.

1. Where clothing is not injured by water, steeping the garments for

half an hour at 12°C. (54°F) in a soap solution containing 2 per cent of trichlorethylene or 10 per cent of tetrachlorethane is effective.

2. Steeping for half an hour in a 5 per cent solution of cyllin in water maintained at 65°C. (149°F.) is also effective on woolen clothes.

3. A mixture of 35 per cent cresol and 65 per cent naphtha soap in water to form a 10 per cent solution is a good wash for body linen, and it may be used on outer clothing by rubbing it in with a brush. The odor will be retained for a long time and will keep lice away for several weeks.

4. A similar mixture is composed of 35 per cent xylol and 65 per cent naphtha soap.

5. A 2 per cent solution of cresyl freshly prepared has been found sufficient to kill all lice with which it comes in contact in 10 minutes. A quart of cresyl in 12½ gallons of water was enough to kill the lice in the body linen of 62 men, each garment being wrung out to recover the liquid as far as possible.

6. A mixture of oils of lemon grass, pennyroyal and eucalyptus 300cc. each and powdered naphthalene 100 grams, when placed in pieces of cloth (6 to 8 drops) and fastened to underclothing at those spots where lice generally congregate will prevent breeding. Five parts of this mixture in 100 parts of alcohol, sprinkled on clothing immediately before ironing is recommended.

7. As an emergency remedy the use of naphthalene in the clothing is quite satisfactory. It seems however that the continuous use of naphthalene is considered injurious to the eyes by some authorities.

Clothing and bedding stored in buildings likely to be contaminated with lice should be treated with naphthalene.

Accoutrements. The accoutrements of the men are often likely to be injured by heat or water. Treatment with trichlorethylene (C_2HCL_3) with a boiling point 88°C. (191°F) and a specific gravity 1.47 is therefore recommended.

Treatment of quarters. Another step as important as freeing the men and their clothing of lice is to insure that the quarters are thoroughly disinsected and the bedding clean. Otherwise no value can come from cleaning the men. The usual practice seems to be to wash thoroughly all walls especially cracks, crannies and corners with 3 to 5 per cent cresol or carbolic solutions, or with kerosene, and then fill up as far as possible the cracks and fumigate with sulphur fumes, using 5 pounds of sulphur to 1000 cubic feet and burning it in little stoves, keeping the room closed 6 hours.

Cyanide gas fumigation is more rapid but also more dangerous. The gas is generated by the addition of sulphuric acid to potassium cyanide or sodium cyanide in earthen jars, or wooden barrels. It is most safely handled as follows: Place in the jar or barrel 2 parts of acid and $2\frac{1}{2}$ parts of water to every part by weight of cyanide to be used. Arrange the cyanide in a package suspended over the jar so that it can be released by the operator, at a distance, by pulling or releasing a cord. The gas is generated very rapidly and is exceedingly dangerous. For lice 10 ounces of cyanide is necessary for each 1000 cubic feet, with an exposure of 2 hours. This fumigation is strong enough to kill all bed bugs, fleas and cockroaches also. When the necessary period of fumigation is over, all doors and windows should be opened from the outside, if possible, and the building thoroughly aired.

Personal treatment. It is often necessary for the individual to use some kind of personal treatment in the absence of bathing facilities or the

opportunity to change clothes. For the pubic louse mercurial ointment, commonly known as blue ointment is usually used. For the head louse, after clipping the hair, treatment with 2 per cent solution of carbolic acid should be effective. The eggs on the head may be destroyed by an ointment made as follows:

Oil of lemon grass	3cc.
Oil of pennyroyal	3cc.
Oil of eucalyptus	3cc.
Powdered naphthalene	1gram.

To each cubic centimeter of such a mixture add 4 grams of vaseline and blend thoroughly.

When powders are used they should not be used at the pubic regions but down the shirt and trousers. One of the most highly recommended substances is called N.C.I.(naphthalene 96 per cent, creosote 2 per cent, iodoform 2 per cent).

A daily anointment of the body with a 25 per cent solution of trichlorethylene, or a twice daily anointment with a 25 per cent solution of petrol in vaseline is very effective in preventing louse breeding. For cleaning the body, bathing or sponging with soap solutions, containing 2 per cent trichlorethylene, or 10 per cent tetrachlorethane, give excellent results.

Precautions for hospitals. In receiving hospitals the floors and walls should be moistened with cresol or carbolic solution. The attendants receiving patients should wear clothes with as few openings as possible. A one piece suit was used by Maitland in Serbia, with the trousers ending in feet. It was fastened by buttons on the shoulders. Sandals were worn in the hospital.

Another good hospital uniform consists of boots, a smooth cape, sleeves

with tight cuffs, and rubber gloves with gauntlets.

If possible, patients should be undressed and washed, have the hair cut and be sent to clean beds.

Treatments for dugouts and trenches. Attention should be taken to cleansing frequently the bedding and other comforts kept in the dugouts. The walls should be scraped and the dust sprinkled with corrosive sublimate and removed. Spraying the trenches with cresol or carbolic solutions should be of some value against the lice, and will help to keep away flies and other insects.

Supplement to Lecture 3. LOUSE BORNE DISEASES.

Since delivering this lecture a number of interesting papers have come to hand.

The British Trench Fever Committee's report, presented by Major Byam (Brith.Med.Journ, May 25,1918, pp.590-591) summarizes the findings of the committee under 18 paragraphs. They proved transmission of the fever by the feces of lice, that the disease is not native to the louse, and that it is not hereditarily transmitted. The feces of the lice were only infective on the eighth to twelfth day after the louse had taken up the virus, proving a developmental cycle in the lice. Transmission by the bite alone was not obtained. The incubation period after inoculation is at least eight days.

On the other hand, Dr.E.L.Opie (Journ.Amr.Med.Assn.,vol.70,No.24, June 15, 1918,p.1888) reporting for the American trench fever committee claims that the fever is transmitted by the bite of the lice from 19 to 25 days after the virus was taken up by the lice. This is probably the sum of the developmental period in the louse and the incubation period after

inoculation. They proved that the virus is not filterable, but is inoculable. The patients were allowed to scratch, and probably this was the way inoculation took place. It is quite possible, however, after lice have been confined on the skin for a time and have consequently covered the entire surface with their excreta, that they may inoculate the virus when they puncture the skin through this film of excreta.

The official statement of the results of the American investigation with a list of names of the volunteers is given by the Secretary of War in the Official Bulletin, June 18, 1918, Vol. 2, No. 338,p.1.

Dr. E.Brumpt (Bul. Soc. Path. Exo t., Vol. 11, No. 3, March 13,1918, pp. 249-258) discusses Rickettsia prowazeki Da Rocha Lima, the socalled cause of typhus fever and claims that it is a coccobacillus and that he found it in 73.6 per cent of the lice (Pediculus corporis) from healthy prisoners in France. He found that these lice infected with this organism remained infective all their lives and therefore concludes that Rickettsia cannot be the cause of typhus fever, even though it may be transmitted by the lice to man and again taken up by them. In experiments on himself with infected lice he did not produce any infection.

W. Dietrich (Zeitschr. f. Immunitätsf., I, Origin., Vol. 26, Dec. 28, 1917, pp. 563-581) in studies of Weil's disease, infectious jaundice, caused by Leptospira icterohaemorrhagiae (Spirochaeta, Spiroschaudinnia) declares that the disease can be carried by Pediculus corporis.

L. Convy, and R. Dujarric de la Rivière (C.R.Soc. Biologie, Vol. 81, January 12, 1918, pp. 22-23) describe Spirochaeta gallica as a probable cause of trench fever.

S.Toyoda (Saikingaku Zasshi, Nos. 250 and 259, Sept. 10, 1916, April 20,1917 - reviewed in Trop.Dis. Bull., Vol. 10, p.271 and Vol. 11, p. 203) claims that Manchurian relapsing fever, a spirochaete disease is transmitted by lice.

Report of a visit to the Marine Camp at

Quantico, Virginia, June 19, 1918.

At the invitation of Dr.W.L.Mann, Post Surgeon, I had the pleasure of visiting the Marine Camp at Quantico, Virginia, and spending the entire day in going over the sanitary work. I was personally escorted throughout the day by Lieut.E.C.Ebert who is directly in charge of the sanitary work.

I was especially interested to find two pharmacists mates, third class, from California who are interested in entomology. These men are Messrs.C.D.Duncan and V.D.Bain. They have an entomological laboratory, and owing to the popularity of the laboratory an exhibition tent has been erected on another part of the grounds which is plainly designated by a painted sign. In this tent are living specimens as well as pinned specimens of disease carrying insects of the camp, and also models of the different devices used for controlling insects. The work of sanitation has been organized by Lieut. Ebert in such a way as to obtain very excellent team work. In fact, the whole organization of the Post Surgeon's office is worked out with the idea of obtaining the greatest amount of efficiency.

On entering the office and a number of the laboratories, one sees a blue print showing in diagrammatic form the entire organization of the Post Surgeon's office. This is divided into two principal groups, the medical and the sanitary. The responsibility is fixed for each phase of the work and groups of men are designated for each activity. In the morning the chiefs of the various boards are given their instructions and they proceed with their work throughout the day according to the instructions.

The largest problem of the camp is necessarily that of mosquito control because of the fact that there are large boggy places in the camp enclosure, and very large swamps adjoining the camp which is located on

the Potomac River. Three separate groups of men are engaged in the work of controlling the mosquito. These are the ditching, the cleaning, and the insecticide details. Practically all of the swamp lands inside the camp have been ditched at least in a preliminary way and in most cases the banks of the ditches have been cleaned of vegetation. As some of this swamp land is daily inundated by the tide water, it can be seen that the task of drainage is a very difficult one. On account of the softness of the ground, water often gathers in foot prints. This makes necessary a very thorough scouting for mosquito breeding places.

It was in the department of the larvacide details that I found probably the most interesting work at the camp. Lieut.Ebert has used his ingenuity and devised a number of very clever pieces of apparatus for the distribution of oil. Crude oil is used as a larvacide but this is very seldom distributed by means of a knapsack sprayer. The ordinary method of spraying is only used on the water barrels, and in cases of emergency, Lieut. Ebert has found that by saturating dry sawdust with druce oil the oil will be given off slowly and more evenly. The oil and sawdust are mixed in approximately the proportion of 30 per cent oil to 70 per cent sawdust. The details in charge of applying insecticides, prepare quantities of the treated sawdust and carry this on their rounds sprinkling a handful on the water in the small breeding holes. A small number of sawdust particles dropped in a puddle of water will quickly form an oil film which will remain for a long time. In streams of running water cross booms consisting merely of two small boards or sticks arranged in the shape of a "V" are anchored across the surface level of the stream. Behind these cross booms a quantity of sawdust impregnated with oil is dropped. The boom is so arranged that a very small amount of oil will pass through or around

it. With a boom placed at intervals the running stream is constantly covered with a film of oil which is not destroyed by rains or by tide, as the boom is so constructed that it will rise with the tide.

An even more clever device consists of a box with two sides screened. This box is filled with oil-impregnated sawdust and placed in the stream, the water flows through the screen and carries out a small amount of oil in a constantly forming film.

Best of all, however, is an automatic oiler devised by Lieut.Ebert by means of which a drop of oil, gauged according to the amount of water to be covered, is periodically released. It is hoped that he will publish a detailed description of this device at an early date.

It would seem to me,from looking over these automatic oilers that possibly they would be of considerable value in the large tide water bays of the Potomac. They could be sunk at regular intervals in these bays while the water is at high tide and replenished every three or four days or whenever the supply ran out. A cross boom of boards anchored by wires placed across the entrance to the bay, with the exception of the channel portion, would assist in retaining the oil film in the bay. It would also be advisable to have the vegetation cut if possible.

Up to date very few mosquitoes have been found breeding, these being mostly Culex. One small stream was found to be breeding Anopheles a short time ago but this has been oiled and the breeding has practically stopped.

On account of the small size of the camp and the difficulty of securing contracts for the disposal of manure and garbage, they are disposed of by incineration. Doctor Mann has given special attention to the subject of incineration and has tried out many different methods. He recently published in the Journal of the American Medical Association, vol. 70, pp.

996-997, a summary of the methods used in the disposal of waste. I had the pleasure of seeing models of the temporary hillside incinerators which are built in emergencies and also of the permanent and semi-permanent incinerators used at the camp. For handling manure and garbage on a temporary basis, an excavation is made in the side of a hill; over this are placed a number of railroad rails and over these rails a wire screen of large mesh. A fire is built in the pit and the garbage and manure are dumped on the wire screen and completely consumed. In the case of the semi-permanent incinerator the waste is dumped on a boiler plate with a drain for carrying off the liquid. A fire is built beneath this and when the substance is completely dry it is shoveled onto another branch of the incinerator which also contains a fire and is completely consumed. The liquid waste flows into an ash pit about six feet in depth and from this drains through a sewer pipe into an evaporation lake covered with a film of oil. There is a grease trap in front of the sewer pipe.

The camp is now using for most purposes the permanent incinerator which is a small building with a furnace in the basement above which is a dome-like combustion chamber. The refuse is dumped from above into the evaporation chambers, which are above the combustion chamber, and falls on a grate. The gases which are formed enter the combustion chamber. The solids fall through to lower slanting grates and are finally consumed. A special chamber is set aside for the cremation of animals. The human waste is carried off by sewage system which empties into the river.

In the case of the civilian employees of the camp who do most of the sanitary work and also other types of labor, and the civilian population of the town, the sewage is on the old style with sanitary boxes which are emptied every day by contract and the fecal matter carried some distance from the camp where it is burned.

The camp authorities have absolute jurisdiction over the sanitation of the town and in order to enforce their rules and regulations they have devised a system of grading all stores. "A plus" means practically perfectly sanitary; "A" is good; "B" if fair and "C" is unsanitary. Each store in the town is graded and the proprietor is permitted to place a sign in his window giving his classification. Of course the sanitary restaurants and markets are very glad to be able to place an "A plus" or an "A" sign in their windows. The other places find that they cannot get business from the marines without raising their standard. The streets of the town are graded in the same way so that the people feel the necessity of keeping their places clean. All weeds and grass must be cut and the garbage and excreta must be removed daily.

The fly prevention work consists of the prevention of breeding, screening, use of fly traps and fly paper. Contrary to the arrangements in army camps, the stables are placed in the opposite end of the grounds from the barracks. The stables have a single set of stalls. They are cleaned daily and the manure sent to the incinerator. Once a week the floors are treated with cresol and crude oil and they are sprinkled with a mixture of borax and lime. By this treatment the floors have become very hard and the same result has been obtained as was found at Camp Meade. A few flies are still breeding somewhere in the camp. Part of these, especially the blow flies, breed in the fish and other water animals which are washed up by the tide. The grease trap from the permanent incinerator is treated with a substance called "coronoleum".

No trouble has been experienced from lice.

In one instance recently a number of mattresses requisitioned from the Quartermaster were found to be heavily infested with bedbugs. This

resulted in the immediate treatment of the building in which these were placed with sulphur fumigation and the cleaning of the bedsteads with turpentine. The mattresses also were given very thorough fumigation.

In only one kitchen has there been any trouble from cockroaches. In this case, apparently the person responsible for reporting the condition of this Company's kitchen overlooked the presence of cockroaches in the storeroom. It was virtually alive with cockroaches but a detail of men was very vigorously combatting the pest. All of the foodstuffs were taken out of doors and the kitchen and storeroom were being sprayed by means of small liquid poison guns, using a substance called "kil-bug". This was being shot all over the walls and directly at the cockroaches. Judging from the odor it is one of the cresol compounds. The walls will also be treated with gasoline and then sodium fluoride will be sprinkled around. It will probably require two or three inspections before this one kitchen can be completely rid of the roaches. This discovery immediately resulted in the tightening of the regulations and a slight reorganization in the method of inspection so as to prevent a recurrence.

The garbage from the kitchens is placed in cans which are tightly covered and kept in a small screened shed which is whitewashed. By means of this method flies are largely prevented from congregating around the garbage cans. When the cans go to the incinerator, they are thoroughly washed and treated with disinfectants.

The supervision of all the manure and garbage disposal is under the medical department but the disposal is under the quartermaster.

One of the most interesting things about the Quantico Camp is the instruction given the hospital corps in practical sanitary measures. In order to make this instruction as practical as possible the men have con-

structed, under the direction of Doctor Mann, models of many different devices. These are all located on a hillside and each device in plainly labeled. Here I saw models of the temporary hillside incinerators, and also a hammock incinerator composed of two wire hammocks hung from trees under which a fire was built, the manure being placed on these hammocks and completely burned. There was a model of Hutchison's maggot trap in operation; also models of camp kitchens, camp eating tables; receiving stations for wounded men; a model of the Serbian barrel steam disinfector and various other types of temporary expedients for disinfection. Many of these are made out of clay pipe, some are made out of brick. The men are encouraged to devise ready means of making whatever they need. At least four types of latrines used in the camp were on exhibition. These are known as the box, bench straddle, and incinerating types of latrines. In the case of the first three types, the pit is gradually filled with earth and lime, while in the incinerating latrine these is a fire built each night which consumes the waste. There is also a urinal soakage pit. A visit to this camp by members of the class would be very instructive.

A class of thirty naval/medical officers was visiting the camp and receiving instruction in the various methods of preparation of such devices, and I was asked to give them a talk on medical entomology. I mentioned the gas tight stall sulphur fume treatment of horses for scabies and one of the doctors suggested the possibility of using this same method for the treatment of men. The suggestion was to place a man in a box such as is used for a vapor bath, and it was also further suggested that the men wear a gas mask so the head could be treated.

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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

Jun 24, 1918. 3:40 p.m.

The seventh session of the class was held in Room 411 Bieber Building in the presence of the following: Abbott, Barber, Basseches, Boving, Caudell, Dusham, Gahan, Gibson, Hoffman, Kneale, Kotinsky, Moles, Perrine, Pierce, St. George, Sanford, Sasscer, Scott, Snyder, Swartzell, Weigel, Whitcomb, White, 23 in all.

Doctor Pierce exhibited additional improved enlarged photographs of Pediculus corporis, especially of nymphs and adult female, after which he read the lecture on "Control of lice".

At the suggestion of Mr. Kotinsky, Doctor Pierce promised to exhibit before the class at a later date samples of the substances used in disinsection referred to in his paper.

Doctor Pierce also read his report of a trip to Quantico. Suggestions were called for to combat Anopheles larvae in deep water, also for a fly trap bait easily procurable at cantonments. A very interesting discussion of camp problems followed.

Requests for Proceedings continue to pour in from entomologists and it is necessary to run off larger editions. Many of the correspondents congratulate the class on its formation and growth and the prophesy is being made that the need of our services will be great before very long.

Every phase of the activity of each member of the class will count in the final summary, hence registry showing attendance is as essential as anything else one may do, and no one can do too much.

Jacob Kotinsky,

Secretary.

Lecture 7. THE RELATION OF CLIMATE AND LIFE AND THEIR BEARINGS ON THE STUDY OF MEDICAL ENTOMOLOGY.

W.Dwight Pierce.

July 1, 1918.

It is necessary to step aside from our course of lectures on insect borne diseases and their control to study a very vital biological subject.

All animal and plant life has its being and reacts according to definite laws in which we find the climatic factor of primary importance. We cannot go far into a subject with as many interrelationships as medical entomology without finding it necessary to know something of the climatic laws which govern the lives of the various organisms concerned.

In the lectures on the biology of the lice attention was especially called to apparent discrepancies in the interpretation of climatic effects on the life of the lice. Throughout my readings I have found a hazy notion of the importance of temperature and still hazier notions of humidity. There is a great deal about these factors which help to govern life that no one knows, but it will pay us to have a clearly set out statement of some of the most important principles as now understood.

On a proper understanding of the relations of temperature and humidity to the life and development of insects, animals and disease organisms depend all transmission experiments, all efforts in keeping alive the various creatures involved, all interpretations of results and many practical measures of control.

I will try to state this difficult subject in as simple language as possible so that you may all see the basic principles at least.

Every one of us knows that cold and heat can cause pain. We have indeed a clear understanding that cold and heat kill. We recognize the

fact that we seem to work best under conditions when we are absolutely oblivious of heat or cold, dryness or moisture. We have felt stupid in murky weather. We have felt parched and dried from extremely dry weather. In other words we can now recognize four conditions which may affect our well being, cold, heat, dryness, moisture. These cannbe expressed on two scales - temperature and relative humidity. In other words we should be able to chart our own susceptibilities to these factors by running for example a temperature scale vertically on our chart paper and a humidity scale from zero to one hundred per cent saturation horizontally.

If we picture our reactions on those of the creature being studied on such a chart we will better understand the subjects. In the lower part of the chart we will locate certain temperatures which always cause death from cold. These may be known as ABSOLUTE FATAL TEMPERATURES.

Now a common failing in the past has been to assume that humidity had nothing to do with the effect of temperatures on life. It does have a very decided bearing. A creature which can stand a certain degree of cold at a given humidity may be abdolutely unable to stand that same temperature and another degree of saturation or relative humidity

Our absolutely fatal temperatures therefore will form some sort of a zone on our chart and this zone will probably be bounded by a curve. We call the temperature below this curve the LOWER ZONE OF FATAL TEMPERATURES. Death caused by cold is called RHIGOPLEGIA.

Slightly above these absolutely fatal temperatures will be a zone of temperatures which might cause death if experienced sufficiently long, but which at least cause a complete suspension of all activity. And still higher will be temperatures which also cause suspension of activity but which do not cause death even when experienced for very long periods.

Formerly this suspension of activity by animal life on account of cold was called hibernation which means winter rest. I have shown (Pierce, W.D. 1916, Journ.Agr.Res.vol.5,pp.1183-1191) that this same inactivity may be caused by dryness or heat and possibly by excessive humidity and that a creature may remain in the same state of inactivity from the heat of summer through the cold of winter and be awakened from it only by the addition of a requisite amount of moisture at effective temperatures. We must seek other terms than hibernation or winter rest and aestivation or summer rest. As this rest consists essentially of an almost complete cessation of all bodily functions, and is a state of insensibility, we may very properly designate the socalled hibernation as RHIGANESTHESIA, or insensibility due to cold. This state may be acquired naturally as winter sets in or may be artificially induced at any time of the year by lowering the temperature. The temperatures inducing RHIGANESTHESIA are grouped into the LOWER ZONE OF INACTIVITY, or the ZONE OF RHIGANESTHESIA.

As the temperatures increase a creature in the state of rest or rhiganesthesia commences to show slow movements of the body fluids, and slight jerky motions, which increase with increase of temperature. This awakening or anastasis when caused by temperature change is a THERMANASTATIS.

The approximate point at any given humidity at which thermanastasis begins is the ZERO OF EFFECTIVE TEMPERATURE. It must be firmly fixed in your minds that there is not a single zero of effective temperature, but a different one for every degree or portion of a degree of relative humidity. In other words at one humidity the awakening may occur at one temperature and under other conditions the temperature may be considerably higher or lower. These points can be connected by a curve which represents the lower

limit of the ZONE OF ACTIVITY or the THERMOFRACTIC ZONE, meaning a zone of effective temperatures

Many authors have manifested considerable confusion in their writings and have even claimed that other authors were incorrect because a certain developmental period or reaction was accomplished in their experiments at a given temperature in a certain period of time while the other investigators obtained totally different results. A man working in a moist coastal section could not justly compare his results with those of a man working in a drier section unless the conditions of humidity were recorded also. For this reason I have maintained that laboratories attempting to correlate temperature with life history must at least be equipped with maximum and minimum thermometers and a sling psychrometer for determining humidity, and that accurate results are based only on a recording hygrothermograph, checked by the above mentioned instruments.

The great bulk of work naturally is upon the reactions which take place in the zone of activity.

It must het be forgotten however that control work depends often upon a correct knowledge of the lower zone of fatal temperatures, and that successful storage of breeding material until the investigation is ready to use it depends often upon a knowledge of the requirements of rhiganesthesia.

Following the awakening the body takes up all its natural functions and we must assume that sustenance is available. The first activities, at temperatures just above zero, are naturally very sluggish and this state of sluggishness may be known as RHIGONOCHELIA, or sluggishness caused by cold.

Some creatures are very sensitive to cold, usually when the humidity is high. Pain produced by the application of cold is called CRYALGESIA. An abnormal sensitiveness to cold is known as CRYESTHESIA, and a morbid

sensitiveness as HYPERCRYALGESIA. These sensations are probably only experienced with a decent of temperatures.

In the zone of effective temperatures or thermopractic zone there is a point or a small restricted zone of temperatures at which all activities are most effective, that is the greatest amount of work is caused with the least amount of exertion and the least loss of energy. This is the so called OPTIMUM, or perhaps better, PRACTICOTATUM, meaning most effective. As temperatures ascend to the practicotatum any given function is performed in proportionately shorter time. As the temperatures ascend above the practicotatum they may be done more rapidly but less accurately or less effectively as, for instance, more eggs may be laid but fewer hatch; but the activity is feverish and soon exhaustion takes place, or the individual gradually becomes more stupid and sluggish. This heat sluggishness is therefore to be called THERMONOCHELIA.

Different reactions to heat may be experienced and these have all received appropriate designations. As for example a stifling sensation is called THERMOPNIGIA; an unusual sensibility to heat THERMALGESIA and a more intense sensibility HYPERTHERMALGESIA. The ability to recognize changes of temperature is THERMESTHESIA and its extreme is designated as THERMOHYPERESTHESIA, an abnormal sensitiveness to heat stimuli. A fondness for heat or requiring great heat for growth is called THERMOPHILIC, while resistance to heat is called THERMOPHYLIC. When a stifling temperature is experienced rapid breathing or THERMOPOLYPNEA is often experienced. Contraction under the action of heat is designated as THERMOSYSTALTIC. The adaptation of the bodily temperature to that of the environment is PECILOTHERMAL. A morbid dread of heat is THERMOPHOBIA. The determination of locomotion by heat is called THERMOTAXIS and movement brought about by

heat THERMOTROPISM.

As the temperatures increase sluggishness increases until sleep or inactivity is induced and this condition once known as aestivation or summer rest may better be known as THERMANESTHESIA or insensibility caused by heat.

The point at which anesthesia begins at any given humidity is the upper boundary of the thermopractic or effective zone. Those temperatures at which successful Thermanesthesia may be experienced embrace the UPPER ZONE OF INACTIVITY, or the ZONE OF THERMANESTHESIA. This quickly merges into those high temperatures which may with sufficient duration of time cause death, and finally those temperatures which are absolutely fatal under all conditions. The highest zone is therefore the UPPER ZONE OF FATAL TEMPERATURES. Death from heat is known as THERMOPLEGIA, or heat stroke.

Most investigators have stopped with a more or less hazy acknowledgement of the existence of these various zones of reactions on the ascending scale of the thermometer but the literature contains few references to similar zones of reactions on the scale of relative humidity. However if we stop to think we must acknowledge that similar reactions do take place.

We may have death from absolute dryness at almost any temperature, in other words we have a condition which is called APOXERAENOSIS, or drying up. At very low humidities one may become insensible and thus we have XERANESTHESIA. Likewise a little higher humidity induces sluggishness or a state of XERONOCHELIA. We have most of us experienced this condition of stupidity in a living room at normal temperatures in the winter due to lack of sufficient moisture. So also there is the humidity which enables each individual to accomplish the greatest results in the least time with the least amount of exhaustion and this is the PRACTICOTATUM. With increase of humidity the activity lessens until an excessively humid atmosphere brings about

HYGRONOCHELIA or sluggishness due to moisture; then HYGRANESTHESIA may be experienced by some species and finally death due to excessive moisture or HYGROPLEGIA.

This makes it obvious therefore that when we plot the reactions of a species to temperature and humidity, we are likely to find a series of closed figures delineating zones of fatal, inactive, active and optimum conditions. Thus it is apparent that Rhigoplegia, Apoxeranosis, Thermoplegia and Hygroplegia form a single zone of temperature-humidities which cause death - this whole zone is the fatal or OLETHRIC ZONE. All other conditions of life lie within it, the next zone being that which includes Rhiganesthesia, Xeranesthesia, Thermanesthesia and Hygranesthesia, the whole zone therefore being the ANESTHETIC ZONE, or zone of rest, which includes the conditions known as hibernation and aestivation. Within this is the THERMOPRACTIC ZONE or zone of effective temperatures, which is naturally made up of subzones representing degrees of activity as the NOCHTILC SUBZONE of sluggish activities on the outside and the PRACTICOTATUM at the center.

Temperatures and humidity affect every bodily function of every creature of the plant and animal kingdom. Some creatures may love cold, some heat, some dryness, some moisture. The pattern of their reactions will therefore shift from one place to another on the chart. Some creatures may be so resistant to cold that fatal temperatures are never normally experienced and rarely artificially. Some may be very resistant to dryness and others capable of standing any degree of humidity. In case of plants the root system receives one set of stimuli and the upper portions another so that the interpretation is not as simple as with animals.

In the different stages of growth a creature may have different ability to withstand extremes.

If the approach to unfavorable or noneffective conditions is gradual the body gradually adjusts and adapts itself for entrance into a dormant state. We find adaptations against cold, heat and dryness, often in cysts or in cases constructed by the creature, and in fact some of these protective cases are made of substances impervious to water. In the state of encystment far greater extremes can be experienced than in the normal state.

Successful dormancy often depends upon the rapidity with which it was brought about. Most creatures practically free the intestinal canal before entering a resting stage.

A sudden lowering or raising of temperature may be fatal at temperatures which would normally be easily withstood if approached gradually.

Alternation of temperature if sudden is often fatal at normally effective temperatures. A creature may become dormant with descending temperatures at a higher temperature than it would awaken with ascending temperatures.

A continuous maintenance of an even temperature and humidity is more or less enervating. A climate which has sufficient variation to allow certain periods of rest from cold at night and heat in the day is probably productive of better results. It is possible in a given day for a creature to have two active and two dormant periods. As for example observations of many insects will show that they sleep during the cold parts of a night, are active during the morning, sleep during the hottest part of the day, are again active in the evening and early parts of the night. It is also noticeable that on humid days many insects are inactive but as soon as the air dries they again resume activity.

Many investigators have failed in keeping insects alive for experiment

because of failure to keep sufficient water present for drinking purposes and evaporation.

As long as any creature is experiencing effective temperatures it must have food available to take when needed. Long periods without food at non-effective temperatures can be experienced, but at effective temperatures the length of life is felatively short. This is a very important point in control work with all insects. If you can deprive them of food for a sufficient period when the climatic conditions enforce activity then control is easy.

There are many very difficult points in this question. Inasmuch as noneffective temperatures and also noneffective humidities may be experienced each day, it becomes necessary to make elaborate studies to ascertain the boundaries of the thermopractic and hygropractic zones, and only a thermo-hygrograph record sheet will enable one to make any kind of a satisfactory study.

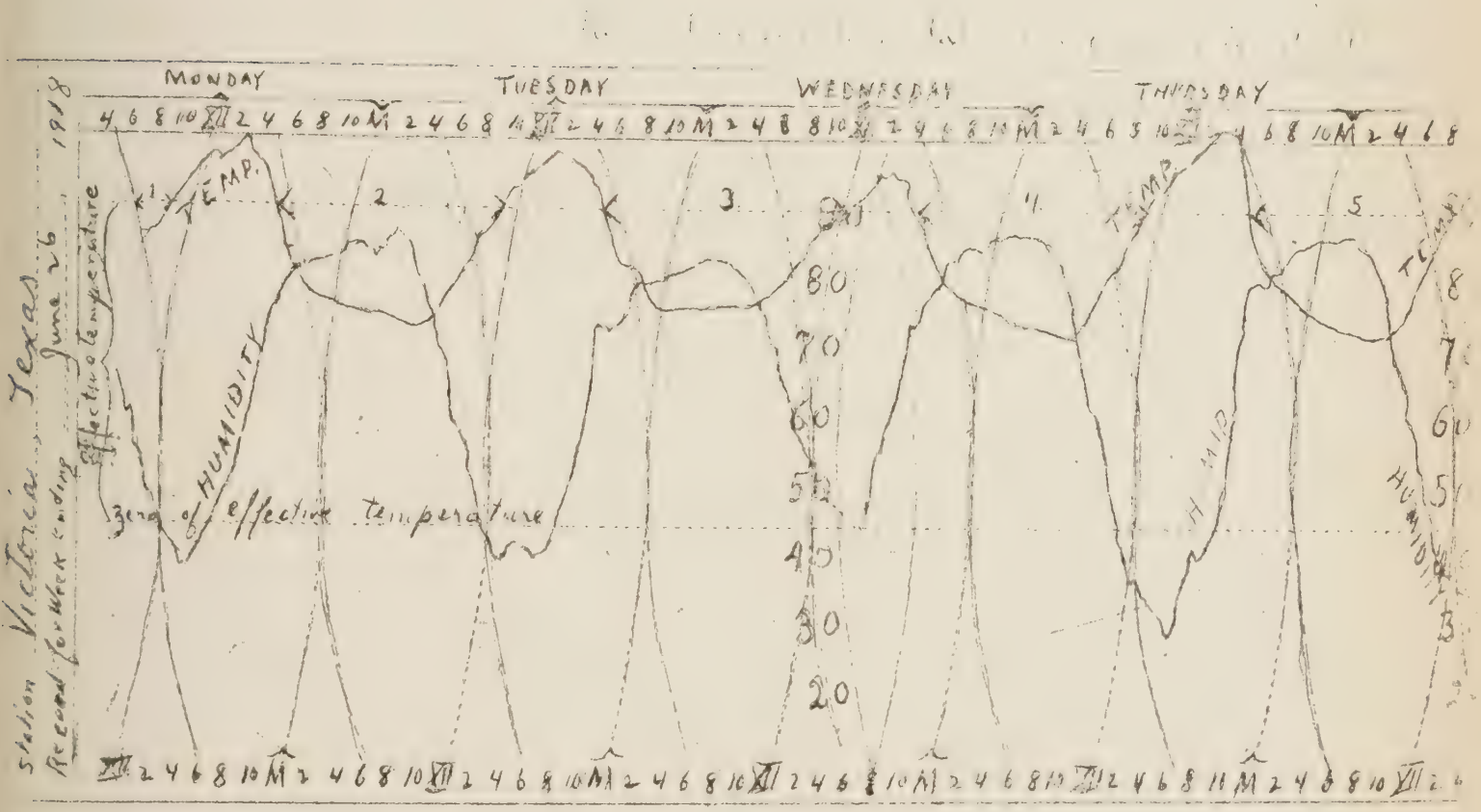
There is a rule which receives much support that a given reaction or stage of development will take an almost constant total effective temperature, which is the multiple of time units by temperature units accumulated above the zero of effective temperature. To compute this one must first eliminate all time, temperature and humidity which was noneffective whether at the top or bottom of the scale. For instance, if at 60% humidity the temperatures 65° to 85° are effective, and during the day the temperature ranged from 50° to 90°, but only during eight hours at the effective temperatures; we must multiply the period 8 hours by the mean temperature experienced between 65° and 85°, considering 65 as 0 and 85 as 20. The result is the total effective temperature of that day. Adding these total effective temperatures

during the total period of the stage we obtain the total effective temperature necessary to bring about the perfection of the stage. Necessarily this is a very complicated proposition which few will desire to work out. Nevertheless once worked out we can establish laws of control which are of utmost value.

Many of the coming lectures will refer to the principles laid down in this lecture and lines of research will be suggested leading toward control measures. The charts given below should be studied in connection with the lecture.

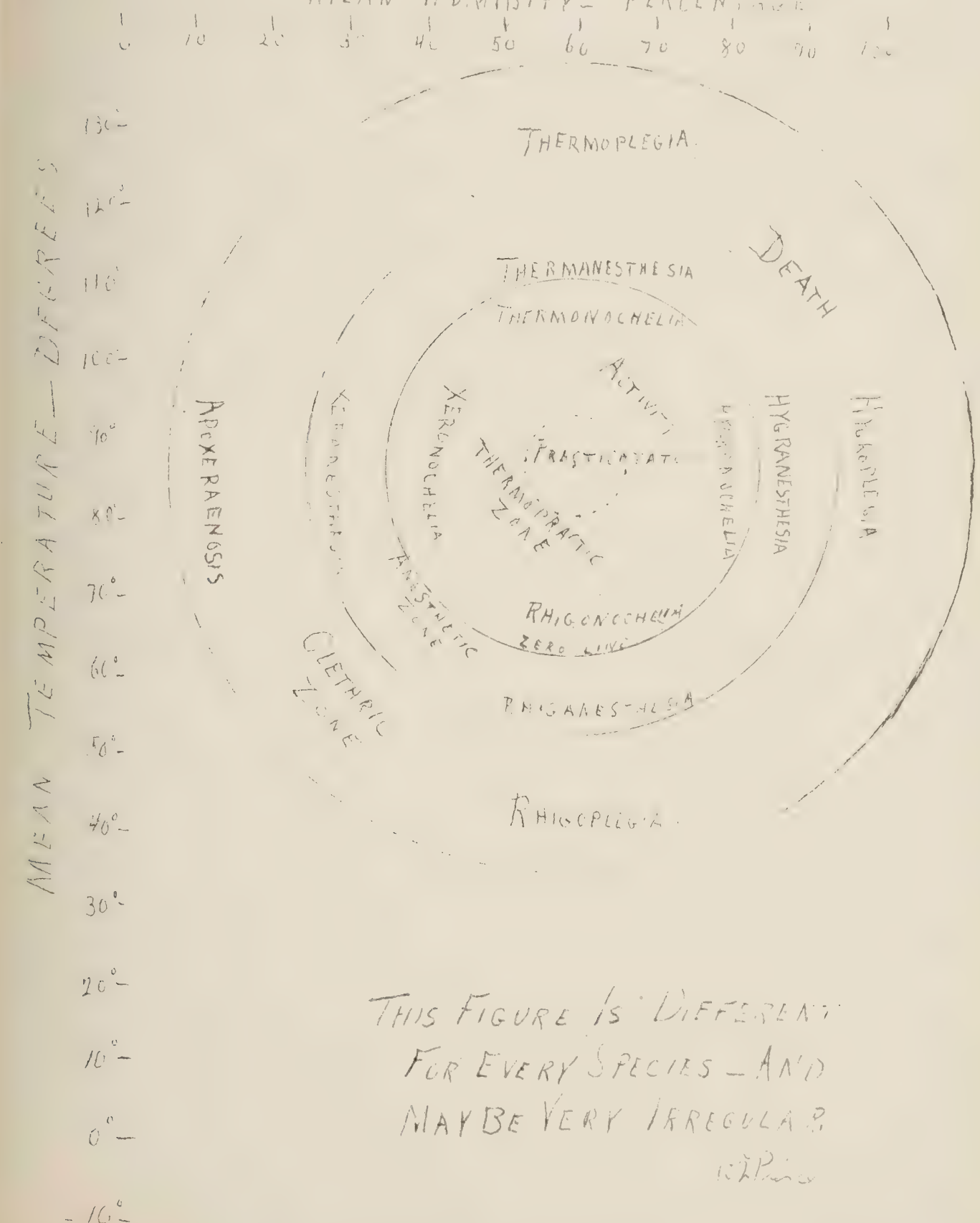
A sample Hygrothermograph Chart with zone of effective temperature marked.

..... Curved line to left = mean relative humidity.
Curved line to right = actual temperature. 8



The periods marked, ← 1,2,3,etc. → are the only effective periods on the chart. The total effective temperature, provided all humidity experienced is effective, is the sum of 1,2,3,4, and 5 measured in hour units multiplied by the average temperature experienced in the zone of effective temperature computed above the zero line. In this example 44° = zero. This average temperature can be figured by measuring each numbered quadrilateral figure with a polar planimeter following the zero base line and the hour lines. This gives the square inches, which divided by the length of the base line gives the average height, which can be measured on the chart and converted into degrees.

Chart Showing The Zones Of Life Reactions To Temperature And Relative Humidity



This Figure Is Different For Every Species – And May Be Very Irregular.

W.R.

BUREAU OF ENTOMOLOGY
★ OCT 7 - 1918 ★
RECEIVED

PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

July 1,1918: 3:40 p.m.

The eighth session of the class was held in room 411 Bieber Building with the following in attendance: Abbott, Barber,Basseches,Dusham, Hoffman, Kneale,Mason,Moles,Perrine,Pierce,Rand,St.George,Scott,Speare, Swartzell,Vierheller,Weigel,White, 18 in all.

Doctor Pierce read reports of insect conditions at three army cantonments.

He then delivered his lecture entitled: "The Relations of Climate and Life and their Bearings on the Study of Medical Entomology", using wall charts to explain his meanings. Incidentally he showed a diagram of a tentative chart of the responses of man to temperature and humidity, pointing out Rosenau's comfort zone of 32 to 55% humidity and 56 to 70°F. as the Practicotatum or Optimum zone. In the thermopractic zone he referred to Huntington's "best work" zone obtained in humid New England as between 50 and 60°F. and 65 to 80% humidity, which zone lies on the same axis as Rosenau's zone. In the sluggish or nochelic zone he referred to Huntington's "rest necessary" at 80°F. and 80% humidity. Huntington also records death from heat stroke at 98% humidity and 89°F. These points serve as a beginning of a chart of human responses to these two factors.

O.H.Basseches,

Acting Secretary.

DO NOT READ THIS PAGE UNTIL YOU HAVE PAPER AND PENCIL.

DO NOT LOOK ANYTHING UP.

These quiz questions are merely a mental drill. They are to be answered as soon as read and immediately mailed to the secretary without correction, so that proper record can be made of your participation in the work. You will find these mental drills very helpful if carried out in the proper spirit. Do not be ashamed to send in even a poorly answered sheet. It will give you more credit than none at all.

QUIZ QUESTIONS.

11. What insect transmits typhus fever and in what ways?

12. Name five diseases transmitted by lice, and the causative organisms if known.

13. Describe four methods of killing lice in clothing.

14. What dry heat exposure is fatal to lice?

15. How can you kill the head louse?

16. What substance can be used to kill the pubic louse?

17. Who was responsible for stopping the typhus outbreak in Servia? How did he do it?

18. Name one or more investigators connected with the proofs of trench fever transmission.

19. Describe method of killing mosquitoes in running water.

20. Describe a complete delousing of an army unit.

SEARCH ASSIGNMENT DUE AUGUST 1, 1918.

Work these questions over carefully. Some day you will have to solve them in actual practice. Work out your theories now.

5. If you took charge of a messhall, the kitchens and store rooms of which were badly infested with cockroaches, what measures would you take to completely rid it of the roaches?

6. If you were appointed sanitary officer of a municipality, what regulations would you make to reduce fly infestation of a large indoor and outdoor city market?

7. If you were a householder and by accident bedbugs became established in one room of the house, what would you do?

8. When you are traveling in rural districts with open privies and unscreened hotels, what sanitary precautions can you personally take to best insure your own health?

Lecture 8. DISEASES BORNE BY NONBITING FLIES.

W.Dwight Pierce.

It will be necessary in discussing the role of flies in the transmission of disease to divide the flies into several categories, because so many species of the order Diptera are involved. The lectures dealing with the flies may not follow each other in strictly logical order because we are endeavoring primarily to look at problems of the hour and we can set aside certain subjects for a later date. The flies can be divided into two large categories, those which bite and those which do not bite but rather sip their food. Two excellent monographs on the relations of flies and disease have been published, that on the non blood suckers by Graham-Smith, and that on the blood suckers by Hindle.

This lecture deals with the non-biting flies only. Among these flies are to be found the principal house visiting flies, foremost among which is the house or typhoid fly, Musca domestica L., followed by the blue bottle blow flies Calliphora vomitoria and C. erythrocephala, the green bottle blow fly Lucilia caesar, and various other species.

The mouth parts of these flies are constructed only for sucking or sipping liquid or semi-liquid foods. In this lecture I can give only a very condensed statement of the relationship of these flies to disease. I would recommend that you devote some of your reading to the books by Hewitt and Graham-Smith quoted in the bibliography. In these books the evidence is given in great detail.

Among the most striking of the investigations into the capacity of non-biting flies for the carriage of disease germs are a series of three excellent papers by the Italian investigator, Cao, whose work is overlooked by many subsequent writers. In fact I have found but one good review of his results. And yet his investigations opened up the way for practically all of the work on bacterial transmission by insects. Working with larvae and adults of Musca domestica, Calliphora vomitoria, Lucilia caesar and Sarcophaga carnaria, he proved that the larvae of these flies could take up and pass through their intestines any bacteria in their food, and that all four species acted exactly alike in this regard. Except where he specifically stated his results applied to all four species in every instance. Step by step he proved that fly larvae take up bacteria from their food, and when breeding in flesh may take up disease germs as well as non-pathogenic germs; that these germs may pass unaltered through the insect's intestine and out in its feces; that some of them may remain for a long period in the intestinal canal, and some even may multiply therein; that

they may be taken up by the larva and persist through its metamorphosis until it arrives at the adult stage, and for days thereafter, and may be carried by this adult and deposited with its feces on food or excrement; and that these bacteria will also be found in the glutinous substances surrounding the eggs when deposited, and thus contaminate the substance in which the newly born larvae will feed; and of course be taken up by this second generation and possibly be distributed farther by it.

These facts were worked out by Cao in 1905 and 1906, and yet Graham-Smith credits Faichnie who worked in India in 1909 with being the first one to suggest that bacteria ingested by the larva might survive the pupal stage and be present in the intestine of the adult. Later Bacot, and also Ledingham in 1911 and Graham-Smith in 1912 corroborated these claims that the bacteria could persist in the body throughout the metamorphosis.

Ledingham (1911), Nicholls (1912), and Graham-Smith (1912) have shown that the fly larvae have great powers of destroying micro-organisms due to the fact that many of these are not adapted to the conditions prevailing in the interior of the larva and pupa, or perhaps more correctly due to the hostile action of bacteria which more normally frequent the intestines of the larvae. These normal inhabitants of the fly intestine are principally non-lactose fermenting organisms.

Not only bacteria but also protozoa, such as the amoebae of dysentery, and the eggs of parasitic worms, may be taken up by fly larvae or adults and deposited in the feces. Roubaud (1918) has brought out the fact that multitudes of the amoebic dysentery germs taken up by adult flies and deposited in their feces die because of the rapid drying of the feces, and he credits the fly with being a great agent in the destruction of multitudes of protozoe, while granting the equally great opportunity of the fly to contaminate

food therewith.

Stiles (1889) fed larvae of Musca domestica with female Ascaris lumbricoides, which they devoured, together with the eggs they contained. The larvae as well as the adult flies contained the eggs of Ascaris. Nicoll (1911) has very thoroughly investigated the relationships of flies to the possible carriage of eggs of worms and demonstrated the ability of adult flies to ingest the eggs of various species of worms, provided these are small enough, and to pass them out whole in the feces, but in all his experiments with the larvae he found that the eggs were crushed.

In addition to the ability of flies to carry disease germs in their body, there are multitudes of proofs of their ability to carry them also on their body and to deposit them when they feed.

The transmission of disease by nonbloodsucking flies is exclusively by contamination either of food, water or wounds. Most of the flies which frequent houses and food or visit man because of attractive secretions or injuries also are attracted to and breed in excreta or garbage. Hence the contamination of food by direct transportation from infected excreta is a very simple matter.

This contamination may be by the simple depositing of disease germs carried on the body of the flies, or by regurgitation, or the deposition of feces. Wherever a fly alights and remains a few minutes it deposits either vomit or feces. By the nature of its breeding it is hardly to be expected that these deposits will not contain some kind of bacteria, and possibly protozoa or worm eggs. If these deposits are made on the moist media offered by foods the germs may easily retain their virulence until eaten.

As flies can travel considerable distances, at least two miles, the

existence of a single disease case with insanitary conditions in the vicinity enabling fly breeding, might easily infect an entire army camp if the flies were permitted to reach the food of the men. It is because of the total lack of sanitary waste disposal in country districts that diseases like typhoid fever and dysentery usually become very wide spread. We can not know the source of the flies which enter our houses. We must not let them visit our food. They must be kept away from the eyes and mouths of babies. Our markets where meats and vegetables are sold must be better protected. I am afraid that only through influencing public opinion will we be able to have the fly nuisance in our own public markets abated. Food offered for sale should be kept under glass or screen at all times.

There are so many organisms transmitted by the nonbloodsucking flies that I shall have to deal with them rather briefly and preferably according to their classification. When you have thoroughly diggsted the mass of matter submitted below, I hope the necessity of fly prevention will be firmly fixed in your minds.

PLANT ORGANISMS CARRIED BY NONBITING FLIES.

PLANT KINGDOM.

THALLOPHYTA: FUNGI: SCHIZOMYCETES: COCCACEAE.

Streptococcus equinus Andrews and Horder, an nonpathogenic organism found in horse dung was found by Torrey (1912) in a number of cases on the surface of city caught flies.

Streptococcus fecalis Andrews and Horder, an organism occurring normally in the human intestine and occasionally pathogenic has been isolated from city caught Musca domestica by Scott (1917), Cox, Lewis and Clyne (1912)

and Torrey.

Streptococcus pyogenes Rosenbach, an organism causing ERYSIPELAS, SUPPURATION and SEPTICAEMIA was isolated by Scott(1917) from city caught Musca domestica in Washington.

Streptococcus salivarius Andrewes and Horder, an organism frequently found in the mouth, but rarely pathogenic has been isolated from the intestines of city caught Musca domestica by Torrey (1912), and was also found on flies by Cox, Lewis and Glynn (1912).

Diplococcus gonorrhoeae Neisser (Gonococcus), the cause of GONORRHOEA, was found by Welander (1896) carried on the feet of fly for three hours after they had been soiled with secretion.

Diplococcus intracellularis meningitidis Weischselbaum (Meningococcus), the cause of CEREBROSPINAL MENINGITIS, is thought to be possibly carried by flies by MacGregor (1917).

Micrococcus flavus was isolated by Torrey (1912) from the intestinal content as well as the surface of city caught flies.

Micrococcus tetragenus Gaffky, commonly found in the human body, sometimes pathogenic, sometimes saprophytic, was isolated from Musca domestica by Scott (1917).

Staphylococcus pyogenes albus Rosenbach, a cause of SEPTICAEMIA was isolated by Cao (1906B) from the mucilaginous envelope covering the eggs of Musca domestica, Sarcophaga vomitoria, Lucilia caesar and Calliphora vomitoria at the time of deposition. Scott (1917) isolated it from the bodies of Musca domestica.

Staphylococcus pyogenes aureus Rosenbach, a frequent cause of ABSCESSES, etc., was shown by Celli (1888) to retain its virulence after passing through the flies' intestines. Herms (1915) proved by experiment that Musca domestica

can carry great numbers of this organism on its feet. Torrey(1912) and Scott (1917) isolated it from the bodies of city caught flies. Cao (1906B) isolated it from the eggs at the time of deposition of laboratory caught flies of Musca domestica, Calliphora vomitoria, Sarcophaga carnaria and Lucilia caesar.

Staphylococcus pyogenes citreus Passet, a pathogenic chromogenic pus forming organism, was isolatedby Scott (1917) from bodies of house flies (musca domestica) in Washington. Cao (1906B) fed larvae of Musca domestica, Sarcophaga carnaria, Calliphora vomitoria, and Lucilia caesar on meat polluted with this organism and recovered it from the feces of mature flies bred from these larvae.

Sarcina aurantiaca Lindner and Koch, a zymogenic, chromogenic (orange yellow) organism found in air and water, rarely pathogenic, was found by Cao (1906B) to becapable of passing through the intestines of larvae of Musca domestica, Calliphora vomitoria, Sarcophaga carnaria, and Lucilia caesar, in all stages of larval growth and of remaining in the body through pupation to maturity

THALLOPHYTA: FUNGI: SCHIZOMYCETES: BACTERIACEAE.

Bacillus of Koch-Weeks, the cause of an acute infectious CONJUNCTIVITIS (pink eye) is thought by Castellani and Chalmers (1913,p.700) to be frequently carried by the little Oscinid gnat, Microneurum funicola, which causes great annoyance by hovering in front of the eyes and attacking the eyes and ears. The flies may be driven away by the odor of Odol.

Bacillus A of Ledingham, a nonlactose fermenter from the feces of children has been found by Tebbutt (1912) to be normal to the house fly,

Musca domestica, being found on the ova, and in the larvae, pupae and adults, and often fed to the larvae survived through the metamorphosis to the adult stage.

Bacillus of Morgan, which is frequently found in cases of INFANTILE DIARRHEA, has been found in various strains commonly in the intestines of Musca domestica by Nicoll (1911), Morgan and Ledingham (1909), Cox, Lewis and Glynn (1912) and Graham-Smith (1912), and the latter found that when fed to larvae of the house fly it could survive through the metamorphosis to the adult fly.

Bacillus acidi lactici Hueppe, a ~~zymogenic ?~~ bacillus common to cow's milk has been isolated from the bodies and from the intestinal contents of Musca domestica in New York, Washington, London and Liverpool by Torrey (1912), Scott (1917), Nicoll (1911), and Cox, Lewis and Glynn (1912).

Bacillus aerogenes capsulatus Welch and Nuttall, a pathogenic organism gaining entrance to the body chiefly through wounds and causing seven infections resulting often in GANGRENE. In the surgery of the present war this organism has been a very important one. It occurs as a normal inhabitant of the intestine of man and some of the animals. It has been isolated by Torrey (1912) from the surface as well as the intestinal contents of city caught flies.

Bacterium anthracis Davaine, the cause of ANTHRAX, although probably more often carried by biting flies has been shown by Davaine (1870) to be capable of carriage by Calliphora vomitoria. He fed flies on anthracic blood and inoculated guinea pigs with parts of these flies 40 hours to 3 days later, obtaining fatal results in 4 out of 7 cases. From flies of Calliphora vomitoria caught in his laboratory Ceo (1906B) isolated viru-

lent germs of B. anthracis adhering to the glutinous secretion surrounding the eggs as they were deposited. He later placed on flesh of animals dead from anthrax externally sterilized eggs of Musca domestica, Calliphora vomitoria, Lucilia caesar and Sarcophaga carnaria and from day to day dissected the larvae feeding of this flesh, always demonstrating anthrax germs in their bodies, and he further proved that these larvae retained the germs in their bodies through pupation to maturity and for at least nine days after maturity. He fed flies on meat polluted with anthrax and demonstrated twenty-four hours later the bacilli in the feces and on the eggs. Graham-Smith (1912) found that many blow flies (Calliphora erythrocephala and Lucilia caesar)which emerged from larvae fed on meat infected with anthrax spores were infected and remained so for 15 days or more. He also found that a large proportion of house flies (Musca domestica) which develop from larvae fed on spores of B. anthracis are infected. Because of the habit of blow flies of breeding in and attacking wounds there have been many cases of human anthrax on the battle front in Europe. The ease with which this may occur is quite evident in view of the above quoted investigations.

Bacillus cloacae Jordan, has been found in the alimentary canal of Musca domestica in London by Nicoll (1911).

Bacillus coli Escherich, an organism normally found in the alimentary canal of man, but often found causing secondary infections, was found by Cao (1906B), in various strains adhering to the eggs at the time of oviposition of flies caught in the laboratory (Musca domestica, Sarcophaga carnaria, Lucilia caesar, and Calliphora vomitoria).

Bacillus coli anaerogenes was isolated by Scott (1917) from Musca domestica caught in Washington.

Bacillus coli communior Dunham, an abundant inhabitant of the human and animal intestine has been isolated from the body and intestinal contents of Musca domestica in New York and Washington by Torrey (1912) and Scott (1917).

Bacillus coli communis Escherich, an organism common in the intestine of man and animals and associated with a large variety of lesions, has been isolated from the body and intestinal contents of Musca domestica, by Torrey (1912), Nicoll (1911), Scott (1917) and Cox, Lewis and Glynn (1912).

Bacillus coli mutabilis was found on the body and in the intestines of Musca domestica in London by Nicoll (1911).

Bacillus "colisimile" Cao, was fed by Cao (1906B) to larvae of Musca domestica, Calliphora vomitoria, Lucilia caesar and Sarcophaga carnaria in flesh and he later demonstrated its abundant presence in the feces of the larvae.

Bacillus cuniculicida Koch and Gaffky, the cause of SEPTICAEMIA in rabbits and guinea pigs, was isolated by Scott (1917) from house flies (Musca domestica)caught in Washington, and he looks upon the fly as the carrier of laboratory epidemics of rabbits and guinea pig septicaemia experienced for several years.

Bacillus diphtheriae Klebs, the cause of DIPHTHERIA, according to experiments performed by Graham-Smith (1910) maybe taken up by flies feeding on infected saliva or sputum and may live in the crop and intestine of the fly for over 24 hours, and in fact in one experiment he twice recovered it from the feces of flies 51 hours after feeding on bacilli emulsified in broth.

Bacillus dysenteriae "Y" Hiss and Russell, one of the organisms found in DYSENTERY and INFANTILE DYSENTERIC DIARRHEA, was experimented with by Tebbutt (1913) who fed it and blood to larvae of Musca domestica. The eggs from which these larvae were hatched were washed in weak carbolic acid or lysol to disinfect them. Before feeding the larvae on the organism they were carefully washed in weak lysol solution. In a limited number of cases the bacillus was recovered from the pupae and adults of larvae thus fed.

Bacillus enteritidis Gaertner, the cause of FOOD POISONING in man, and epizootic diseases among animals was experimented with by Graham-Smith (1912), who fed it to the larvae of Calliphora erythrocephala and Musca domestica, but did not recover it in the adults matured from these larvae. Cox, Lewis and Glynn (1912) isolated a similar bacillus from flies caught in Liverpool.

Bacillus fecalis alkaligenes Petruschky, a not infrequent inhabitant of the human intestine, which has been associated with a case of severe gastroenteritis, was isolated by Torrey (1912) from the intestinal content of city caught flies in two different instances.

Bacillus fluorescens liquefaciens Fluegge, a common organism found in water and air was fed by Cao (1906 B) to larvae of Musca domestica, Calliphora vomitoria, Lucilia caesar, and Sarcophaga carnaria, on flesh containing the organisms, and found among the predominant bacteria in the feces of the larvae. He found that this organism taken up by the larvae could persist through the pupal stage and be obtained from the feces of flies immediately after their emergence, and when fed to adults it was demonstrated on their eggs when deposited.

Bacillus fluorescens nonliquefaciens Eisenberg and Krueger, found in water and in butter, was fed by Cao (1906B) to larvae of Musca domestica, Calliphora vomitoria, Lucilia caesar, and Sarcophaga carnaria, and later demonstrated in the feces of the larvae.

Bacillus mesoformans nonliquefaciens was found on the body and in the alimentary canal of Musca domestica caught in London by Nicoll (1911).

Bacillus grünthal was found on the body and in the intestines of Musca domestica by Nicoll (1911).

Bacillus lactis acidi Marpmann, a zymogenic bacillus found in cow's milk, was isolated by Torrey (1912) from the surface of city caught flies.

Bacillus lactis aerogenes Escherich, which is almost constantly found in milk and is one of the chief causes of souring of milk was isolated from flies by Cox, Lewis and Glynn (1912).

Bacillus leprae Hanson, cause of LEPROSY, may be carried by Musca domestica, according to Leboeuf (1913).

Bacillus mallei löffler and Shutz may be transmitted by flies according to Rosenau (1916).

Bacillus neapolitanus has been found on the body of Musca domestica by Nicoll (1911) and Cox, Lewis and Glynn (1912).

Bacillus oxytocus perniciosus Wyssokowitsch, a pathogenic organism found in milk has been isolated from the intestines of Musca domestica by Nicoll (1911).

Bacillus paracoli Duval and Schorer, a pathogenic organism found frequently in the stools of children suffering from summer diarrhea, has been isolated several times by Torrey (1912) in New York, both from the surface and intestines of city caught flies.

Bacillus paratyphosus "A" Schottmüller, cause of PARATYPHOID A. fever

was isolated from the intestinal contents of city caught flies by Torrey (1912).

Bacillus paratyphosus "B" Schottmüller, cause of PARATYPHOID B fever, was recovered from the body and intestines of Musca domestica caught in London by Nicoll (1911), with the evidence that it had been carried by the flies at least for 11 days.

Bacillus pestis Kitasato, the cause of BUBONIC PLAGUE, although normally carried by fleas, has been shown by Yersin (1894) and Nuttall (1897) capable of remaining in the intestines of flies in a virulent condition for at least 48 hours after infection. Nuttall's experiments indicated that this bacillus is fatal to Musca domestica.

Bacillus prodigiosus Ehrenberg, a nonpathogenic, zymogenic and chromogenic organism was fed by Cao (1906B) to adult flies of Musca domestica, Calliphora vomitoria, Lucilia caesar, and Sarcophaga carraria and was demonin their feces and on their eggs 24 hours later. Larvae fed on polluted meat contained the germs in their bodies and carried them through pupation and they could be demonstrated in the intestines of the adult up to nine days after emergence. Ledingham (1911) corroborated Cao's findings of the persistence of this bacillus throughout the metamorphosis of Musca domestica. Graham-Smith (1913) found that flies of Musca domestica fed on this bacillus may infect milk for several days, while Calliphora vomitoria flies when infected constantly produced infection in milk up to the eighth day and in syrup up to the twenty-ninth day.

Bacillus proteus vulgaris Hauser, B.p. mirabilis Hauser, and B.p. zenkeri were fed by Cao (1906B) to larvae of Musca domestica, Calliphora vomitoria, Sarcophaga carnaria, and Lucilia caesar, and were found abundantly in the feces of the larvae so fed. Species of Proteus were also

found deposited with the eggs of flies fed on infected flesh. Bacillus proteus vulgaris was isolated by Scott (1917) from Musca domestica caught in Washington.

Bacillus pyocaneus Gessard associated with SUPPURATING WOUNDS in which blue-green pus is present was isolated in two strains from flies caught in Liverpool by Cox, Lewis and Glynn (1912). Bacot and Ledingham (1911) by carefully controlled experiments have proved that the larvae of Musca domestica fed on infected food retain this bacillus in the gut through the metamorphosis to the adult stage and may distribute it in their excreta.

Bacillus radiciformis Tataroff, a saprophytic organism found in water, was fed by Cao (1906B) to larvae of Musca domestica, Calliphora vomitoria, Lucilia caesar and Sarcophaga carnaria, and recovered from the feces of the larvae.

Bacillus ruber kielensis Breunig, a chromoparous (red) bacillus found in water at Kiel was fed by Cao (1906B) to larvae of Musca domestica, Sarcophaga carnaria, Calliphora vomitoria and Lucilia caesar, and he demonstrated that the larvae could take it up in all stages of growth, and that the bacilli persisted in their bodies through pupation to maturity.

Bacillus schafferi Freudenreich, a nonpathogenic, zymogenic organism, found in "puffy" and "Nissler" cheese has been found by Nicoll (1911) in London on the body and in the intestines of Musca domestica.

Bacillus septicus agrigenus Nicolaier, a pathogenic organism was fed by Marpmann (1897) to flies, and 12 hours later the contents of the flies were inoculated into mice, producing fatal infection in a large percent of the inoculations (Nuttall 1899).

Bacillus "similcarbonchio" Cao, a pathogenic organism similar to Bacillus anthracis, which produces CARBUNCLES when inoculated was fed by Cao (1906B) to larvae of Musca domestica, Calliphora vomitoria, Lucilia caesar, and Sarcophaga carnaria and isolated from the feces of the larvae in a very virulent strain. In examinations of many flies caught in the laboratory he occasionally isolated a nonpathogenic, mobile strain of this organism.

Bacillus subtilis Ehrenberg, an organism frequently found in air, water, and soil and seldom pathogenic was fed by Cao (1906 B) to larvae of Musca domestica, Calliphora vomitoria, Lucilia caesar and Sarcophaga carnaria and was among the predominant bacteria recovered from the feces of the larvae.

Bacillus suipestifer Salmon and Smith, often found in cases of FOOD POISONING and SUMMER DIARRHEA is recorded by Scott (1917) from the house fly, Musca domestica.

Bacillus "tifosimile" Cao, a pathogenic organism strongly resembling B. typhosus was fed by Cao (1906B) to larvae of Musca domestica, Calliphora vomitoria, Lucilia caesar, and Sarcophaga carnaria and later demonstrated in the feces of the larvae as among the predominant forms in strains of differing virulence. From flies caught around the laboratory he isolated pathogenic strains adhering to the eggs when deposited.

Bacillus tuberculosis Koch, the cause of TUBERCULOSIS, was found in four out of six flies caught by Hofman (1888) in the room of a tuberculosis patient, whose sputum had contained many germs. Flies fed artificially with sputum died in a few days. Within twenty-four hours of their being fed on the sputum, the tubercle bacilli appeared in their excreta. A guinea pig inoculated with the intestines of flies developed tuberculosis.

Celli (1888) reports Alessi's experiments of inoculating the feces of flies fed on tubercular sputum, and causing the development of tuberculosis in two rabbits. Spillman and Haushalter (1887) were however the first to find the tuberclesbacilli from sputum and disseminate the same in their feces for at least five days.

Bacterium tularense McCoy and Chapin, cause of a fatal RODENT PLAGUE of which a few human cases are on record may be transmitted by Musca domestica. Wayson (1915) inoculated the crushed bodies of flies fed on the viscera of an animal dead 48 hours and obtained fatal results in three series of experiments with guinea pigs.

Bacillus typhosus Eberth, the cause of TYPHOID fever, was first shown by Celli (1888) to be capable of passing through the intestines and into the feces of flies. Many authors have added proofs of the role of the fly in the transmission of this disease and these are ably summarized by Graham-Smith (1913) and Hewitt (1914). Faichnie (1909) proved that flies could carry this bacillus in their intestines for 16 days. Ledingham has isolated the bacillus from the intestines of Musca domestica which had fed on it in the larval stage, but found that the normal bacilli in the larval intestines usually prevent its successful survival through metamorphosis.

Bacillus vesiculosus, which is very frequently found in human excrement, was found on the body of Musca domestica caught in London by Nicoll (1911).

Bacillus xerosis Kutschert and Neisser, a presumably nonpathogenic organism, usually found in the eyes, and often associated with conjunctivitis was isolated by Torrey (1912) on the surface of city caught flies.

THALLOPHYTA: FUNGI: SCHIZOMYCETES: SPIRILLACEAE.

Spirillum (Vibrio)cholerae Koch, the cause of ASIATIC CHOLERA may be carried by flies. The connection of flies with the prevalence of cholera was first noted by Nicholas (1873). Maddox (1885) first performed experiments with Calliphora vomitoria and Eristalis tenax as well as other insects and determined microscopically the presence of the motile cholera vibrios in the feces. Tizzoni and Cattoni (1886) caught flies in cholera wards and after several hours obtained characteristic cultures of the organism. Many other authors, as Sawtchenke (1892), Simmonds (1893), Uffelman (1892), Macrae (1894), have furnished proofs of fly dissemination of the cholera vibrio, a summary of which can be found in the books by Graham-Smith, and Hewitt.

The subject will be continued in Lecture 9 which will contain a bibliography of the works cited.

BUREAU OF ENTOMOLOGY
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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

July 8, 1918: 3:40 p.m.

The ninth session of the class was held in Room 411 Bieber Building, with the following in attendance: Abbott, Baker, Barber, Boving, Boyd, Duncan, Gahan, Hoffman, Kneale, Kotinsky, Mason, Middleton, Moles, Morrison, Perrine, Pierce, Reed, St.George, Sasscer, Snyder, Swigman, Weigel, Whitcomb, White, 24 in all.

The secretary read abstracts from a number of letters received from entomologists and army sanitarians, the general tone of which give approval of and encouragement in the work and prediction of useful service. The leader spoke of entomologists who had been drafted and their services utilized as entomologists in the sanitary organizations of their respective camps, often with early promotion to sergeancy.

In reply to an inquiry of Mr.Kotinsky as to the relative degrees of humidity and temperature requisite for keeping an insect in a definite state of activity, in other words, how much for instance would the humidity percentage have to rise per one per cent fall of temperature for an insect to retain a certain state of activity, elicited the reply of the leader that this ratio would differ for each species of insect and that one or the other factor might be the stronger.

Mr.Kotinsky further inquired why the study was limited to the two elements of climate when others, such as sunlight for example, are so vital. In reply, Doctor Pierce stated that the only two factors which have been measured in their effect on life are temperature and humidity, and that undoubtedly sunlight, especially the actinic rays, atmospheric pressure, and many pther factors influence life reactions. Since the reactions to

temperature and humidity are easily chartable and time-coordinated records can be obtained, and more so because everyone is familiar with these two factors, they are therefore the factors first to be considered.

He then read his first lecture on "Diseases Transmitted by non-biting Flies".

The meeting adjourned at 4:30 p.m.

J. Kotinsky,
Secretary.

Lecture 9. DISEASES BORNE BY NON BITING FLIES-CONTINUED.

W.Dwight Pierce.

In the lecture of last week I presented a large mass of data on the transmission of plant organisms, mainly bacteria, by flies. It was intended that the entire subject of disease transmission be covered in one lecture, but you can readily see that an adequate presentation of the basic argumentative material requires at least two lectures.

A brief survey of the data presented will perhaps help to imprint the gravity of the fly menace to all who read the lecture. Sixty three minute plant organisms have been shown to be transmissible by domestic flies. Forty-four of these organisms have been found on or in flies caught in cities or buildings, in other words were naturally carried by so called "wild flies". Among these forty-four organisms naturally carried by flies were several normal inhabitants of milk, also various normal inhabitants of the human and of animal intestines, which could only be taken up from excrement. Some of these organisms are taken from eyes, some from sputum, some from decaying vegetable matter, others from dairy products. The fly containing such organisms betrays its habits. We find the organisms of conjunctivitis, infantile diarrhea, sour milk, gas gangrene, enteritis, guinea pig septicaemia, leprosy, paratyphoid A, and paratyphoid B fevers, bubonic plague, green pus, food poisoning, tuberculosis, typhoid fever, anthrax, rodent plague, gonorrhea, abscesses, erysipelas, and cholera, and possibly cerebrospinal meningitis, normally carried by flies which frequent our houses, visit our bodies and pollute our food with their excreta. We also find experimental evidence that these same flies can

carry the organisms of diphtheria, bacillary dysentery, gastroenteritis, and other pathogenic conditions.

In other words it would seem that nonbloodsucking flies can carry any bacterial or coccal disease in which the organism may be reached by the fly fly on the body of the person, in his sputum or his excreta, and undoubtedly the same is true of such diseases of animals.

It is of interest to note that in nineteen species the organism has been proven to pass freely through the intestinal canal of the larvae, in thirty seven species through the intestines of the adult, and in eleven species to be capable of persisting in the larvae through metamorphosis to the adult. What greater argument could be found that flies are dangerous not only because of what they as flies have fed on but also because of food they took while larvae, possibly a long distance away.

We have not however gauged the depth of the fly's infamy, as we have so far only listed the evidence of plant diseases transmitted. I will now treat in a similar manner the evidence of transmission of animal organisms by these same flies.

PROTOZOA: SARCODINA : AMOEBINA : AMOEBIDAE.

Löschia coli Lösch (Entamoeba) a supposedly harmless commensal in the alimentary canal of man, where it feeds on the contents of the bowels may be carried in the encysted form by Musca domestica, according to Roubaud (1918), who finds that the cysts readily pass through the fly intestines at laboratory temperatures of 15-18°C. (59-65°F.) in 24 hours. It may be carried from infected stools to food but must be deposited in moist substances, as all cysts dry rapidly in dry fly feces.

Löschia histolytica Schaudinn, the cause of AMOEBIC DYSENTERY, may be carried in the encysted form by Musca domestica and Calliphora erythrocephala according to Flu (1916). Roubaud (1918) has carefully investigated and finds that the free amoeba is quickly digested by the fly, but the cysts may pass readily through the intestines within 24 hours and may be demonstrated up to 40 hours. The cysts die rapidly in dry fly feces, and therefore to live must be placed on moist substances, or on food.

PROTOZOA : MASTIGOPHORA : PROTOMONADINA : BODONIDAE.

Provazekia sp. is found in Fannia canicularis (Dunkerley 1912).

PROTOZOA : MASTIGOPHORA: POLYMASTIGINA: POLYMASTIGIDAE.

Giardia intestinalis Lamol (Lamblia), the cause of LAMBLIAN DYSENTERY of rodents and man, may be carried in the encysted form by Musca domestica, according to Roubaud (1918), but must be deposited in the feces on moist substances, or directly on food.

PROTOZOA : MASTIGOPHORA: BINUCLEATA: LEPTOMONIDAE.

Crithidia calliphorae Swellengrebel is described as a parasite of Calliphora erythrocephala.

Crithidia muscae-domesticae Werner is described as a parasite of Musca domestica

Leptomonas calliphorae Swingle is a parasite of Calliphora erythrocephala.

Leptomonas homalomyiae Brug is a parasite of Fannia scalaris.

Leptomonas lineata Swingle is a parasite of Sarcophaga sarraceniae.

Leptomonas luciliae Strickland is a parasite of Lucilia sp.

Leptomonas luciliae Roubaud is described as a parasite of Lucilia serenissima.

Leptomonas mesnili Roubaud is a parasite of Lucilia sp.

Leptomonas muscae-domesticae Burnett is a parasite of Musca domestica, M. nebulo, Fannia scalaris, Pollonia rudis, Teichomyza fusca, Lucilia sp., Pycnosoma putorium, Scatophaga lutaria, Neuroctena anilis, Homalomyia corvina, and Sarcophaga murus, undergoing complete metamorphosis in the bodies of the flies. Patton (1910) has demonstrated that the disease may be transmitted from fly to fly as follows: the food becomes infected from the feces of the infected flies which have fed on it; uninfected flies may become infected by ingesting either the long flagellates, the short encysting forms, or the cysts.

Leptomonas pycnosomae Roubaud is a parasite of Pycnosoma putorium.

Leptomonas roubaudi Chatton is a parasite in the malpighian glands of Drosophila confusa.

Leptomonas sarcophagae Prowazek is a parasite in the gut of Sarcophaga haemorrhoidalis and another species of Sarcophaga.

Leptomonas soudanensis Roubaud is a parasite of Pycnosoma putorium

Leptomonas stratiomyiae Fantham and Porter is a parasite of Stratiomyia chameleon and S. potamida. Fantham and Porter (1913) proved it experimentally pathogenic by inoculation to Mus musculus.

Leishmania tropica Wright, the cause of ORIENTAL SORE of man, may be taken up in the crithidial stage by Musca domestica and the organism demonstrated 48 hours after feeding, according to Carter (1909). According to Wenyon(1911) who investigated Bagdad sore, Musca domestica may readily feed on the sores and take up Leishmania, but there is no development of the organism and no parasites were found in the feces. On the other hand, Row, working with Cambay sore believed the organism transmissible by

Musca domestica up to three hours after the fly had fed on infected sores. He found the gut contents of flies infective for a monkey three hours after the fly had taken up Leishmania, but Patton (1912) maintains that Camay sore never commences in a cut, scratch or abrasion, and failed to transmit the disease in this manner in numerous experiments with Musca nebulo and Musca sp. A new investigation however is warranted by Row's statement, seeking fecal infection of wounds.

Rhynchoidomonas luciliae Patton is parasitic in the Malpighian tubules of Musca nebulo and Lucilia serenissima.

PROTOZOA: MASTIGOPHORA : BINUCLEATA: TRYPANOSOMIDAE.

Trypanosoma evansi Steel, the cause of SURRA, an African disease of horses and other mammals may be carried by Musca domestica by contact with wounds.

Trypanosoma hippicum Darling, the cause of MURRINA a disease of horses and mules in the United States and Panama, may be carried according to Darling (1911,1912) by Musca domestica, Chrysomyia and Sarcophaga, from wounds by mechanical transmission. He ascertained that the trypanosomes remained alive in the proboscis of the fly at least two hours, and he also successfully inoculated a mouse with the crushed portions of a proboscis of a fly which had fed on infected blood. Isolation of the animals from fly attack, and binding up of wounds wiped out the epidemic. He did not ascertain whether the trypanosome might pass out of the fly's feces and contaminate lesions in this manner, which naturally is the normal method of fly transmission.

PROTOZOA: MASTIGOPHORA: SPIROCHAETACEA: SPIROCHAETIDAE.

Treponema pertenue Castellani, the cause of YAWS, an infectious disease of man may be transmitted by the house fly, Musca domestica. Castellani in Ceylon (1907) found that flies eagerly crowd around on the open sores of yaws patients. In the hospitals as soon as the dressings were removed from the yaws ulcerations they became covered with flies, sucking with avidity the secretion, which they may afterward deposit in the same way on ordinary ulcers on other people. He conducted experiments which proved that the flies do take up the organism, which he recovered from the dissected mouth parts. He fed flies on the organism, then removed their appendages and fastened them over scarified areas of skin of monkeys, and obtained in two experiments positive lesions by this organism. Robertson (1908) also definitely obtained this spirochaete from flies collected on yaws lesions. Nicholls (1912) ascribes most of the cases of yaws in the West Indies to inoculation of surface injuries by Oscinis pallipes. Sarcophaga is also considered a carrier. None of the experiments have been directed at obtaining infection through the deposition of the spirochaetes, taken up by the fly in feeding, in its feces on other ulcers or injuries. This would appear to be the most likely method of infection.

PROTOZOA: NEOSPORIDIA: MYXOSPORIDIA: NOSEMIDAE.

Nosema apis Zander a bee disease may be communicated to Calliphora vomitoria and other insects through feeding on the bee extréta around bee hives.

PROTOZOA: NEOSPORIDIA: MYXOSPORIDIA: THELOHANIDAE.

Octosporea monospora Chatton and Krempf is a parasite of Fannia scalaris.

Thelohania ovata Dunkerley is also a parasite of Fannia scalaris.

DISEASES OF UNSETTLED ORIGIN PROBABLY CAUSED BY MICROORGANISMS.

PURULENT OPHTHALMIA is said to be carried by flies in Egypt. Brumpt accuses Musca domestica of being a carrier of TRACHOMA. Rosenau states that flies have been found breeding in open lesions of SMALLPOX, and that flies may transmit MEASLES and SCARLET FEVER. Definite experiments certainly should be carried out with a view to determining the exact relationship of flies to these diseases, seeking first the possibility of transmission by fecal contamination.

HIGHER ORGANISMS CARRIED BY FLIES.

As pointed out in the introduction of the last lecture flies can carry the eggs of higher organisms. The evidence is presented below.

PLATYHELMIA: CESTOIDEA: CYCLOPHYLLIDEA: TAENIIDAE.

Taenia (Taeniarhynchus) saginata Goeze, the FAT TAPEWORM of cattle and rarely of man, is naturally carried in the egg stage by Musca domestica in British East Africa according to Shircore (1916). It is necessary that the eggs, passed in human or animal feces, reach the food or water of the next host. This may occur by means of insanitary sewage disposal, and also quite probably, often by the agency of flies.

PLATYHELMIA: CESTOIDEA: CYCLOPHYLLIDEA: HYMENOLEPIDIDAE.

Choanotaenia infundibulum Bloch, the FOWL TAPEWORM, develops to the cysticercoid stage in Musca domestica fed on the eggs, and Gutberlet (1916) succeeded in infecting new born chicks by feeding them on infected Musca domestica.

Davainea cesticillus Molin, a fowl tapeworm, was tested with negative results by Gutberlet (1916), using Musca domestica and Calliphora vomitoria in his search for the intermediate host.

Davainea tetragona Molin, another chicken tapeworm, likewise gave Gutberlet (1916) negative results with the same two species of flies.

PLATYHELMIA: TREMATODA: MALACOTYLEA: SCHISTOSOMIDAE.

Schistosoma mansoni Sambon, the trematode worm causing intestinal Schistomiasis of man or BILHARZIOSIS, may be transmitted in the egg stage by Musca domestica, according to Shircore (1916), who found them naturally so carried in British East Africa. The cercaria stage is passed in a snail.

NEMATHELMINTHES: NEMATODA: SPIRURIDAE.

Habronema muscae Carter, a STOMACH WORM OF HORSES passes its earlier stages in Musca domestica, according to Ransom (1913). Either the egg or first stage larva is ingested by the fly larva breeding in horse manure. Development goes on within the fly larva and pupa, the last fly stage being found in the proboscis of the adult fly. Whether the worm leaves the fly's proboscis while the latter is feeding or is eaten with the fly by the horse, has not been determined.

NEMATHELMINTHES: NEMATODA: ASCARIDAE.

Ascaris lumbricoides Linnaeus the cause of HUMAN ASCARIASIS does not require an intermediate host. Stiles in 1889 fed Musca domestica larvae on female Ascaris and later found the eggs in different stages of development in both larvae and adult flies (Graham-Smith 1913). Shircore

(1916) in British East Africa found the eggs in the intestines of Musca domestica in nature. Nicholls (1912) in St.Lucia found the eggs in the abdomens of flies, Limosina punctipennis, taken at fecal matter.

NEMATHELMINTHES: NEMATODA: OXYURIDAE.

Oxyuris curvula Rudolphi, the cause of EQUINE PIN WORMS is recorded by Patton and Cragg (1913), as probably the species of Oxyuris, which in Madras is often found in the embryo stage heavily infesting the larvae of Musca nebulo.

Oxyuris vermicularis Linnaeus, the cause of human PIN ITCH, can be ingested in the egg stage by flies, according to Grassi (1883).

NEMATHELMINTHES: NEMATODA: AGCHYLOSTOMA.

Agchylostoma duodenale Dubini, cause of HOOKWORM disease of man, has been found in the egg stage in house flies, Musca domestica, by Shircore (1916) in British East Africa, and it is therefore possible that the eggs may be placed on food, in which the hook worm larva could hatch and be directly conveyed into the body with the food. No development takes place in the flies.

Necator americanus Stiles, the American HOOK WORM was collected in the egg stage in the intestines of Limosina punctipennis in St.Lucia by Nicolls (1912). Galli-Valerio (1905) found that flies could carry on the surface of their bodies,not only the eggs but also the larvae of this worm.

NEMATHELMINTHES: NEMATODA: TRICHOSOMIDAE.

Trichuris trichiura Roederer and Wagler, the WHIP WORM of man was

collected in the egg stage by Shircore(1916) in British East Africa in the abdomen of Musca domestica and by Nicholls (1913) in St.Lucia in the abdomen of Limosina punctipennis, and the latter succeeded in feeding Musca domestica on the eggs. It probably does not require the flies as immediate hosts, but is undoubtedly distributed in this manner.

Thus to the already long list of serious diseases caused by the fly we may now add amoebic dysentery, Lamblian dysentery, Oriental sore, surra, murrina, yaws, purulent ophthalmia, trachoma, the fat tapeworm of cattle, the fowl tapeworm, bilharziosis of man, the stomach worm of horses, human ascariasis, equine pin worms, pin itch, two hook worms, and the whip worm, and possibly also smallpox, measles and scarlet fever.

We found that the bacteria were only mechanically carried by the flies, except in the case of Bacillus anthracis. Among the protozoa also those organisms parasitic in vertebrates all seem to be mechanically transmitted. The various parasites mentioned however pass complete life cycles in the body of the fly. Among the worms, however, there are cases of external mechanical carriage, transmission of eggs through the intestinal canal, retention of the egg from larva to adult fly (Ascaris lumbricoides), and also cases of the fly serving as an intermediate host (Choanotaenia infundibulum, and Habronema muscae). The last named worm is the only organism transmitted by the fly which works forward into the proboscis for transmission at time of feeding.

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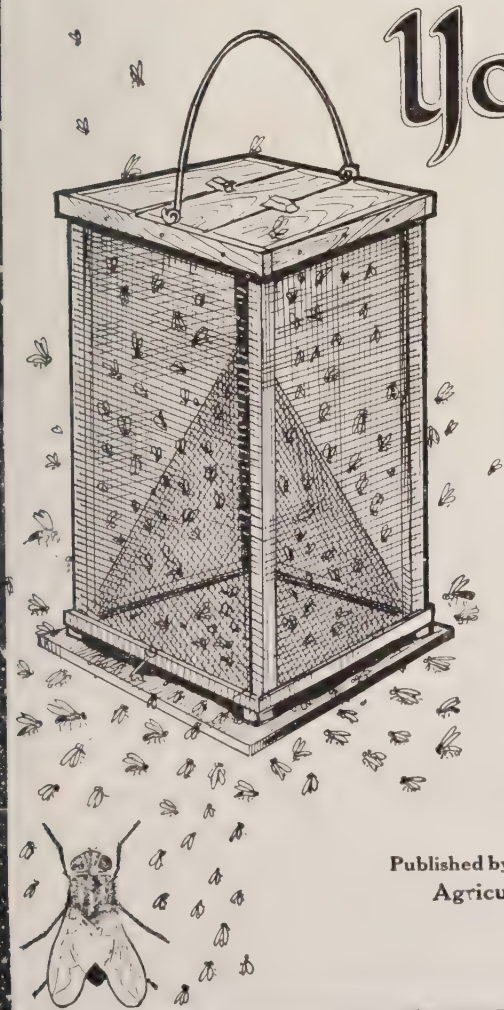
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Make Up Your Mind That you will not have

FLIES in the HOUSE

90% of The Flies Breed in Horse Manure

You can



Report Manure Piles, Dead Dogs, Cats and Rats to Health Office.

Keep the Yards Clean.

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Trap the Fly Before He Gets in.

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Keep Everlastingly at it.

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RAY McGILL.

ANY BOY CAN MAKE A FLY TRAP

(See Directions Inside)

One boy in Cook County last year made $46 selling fly traps to the neighbors.

Wire screen, nails and tacks cost about 40 cents. The frame can be made from a pine box.

Hang the fly trap eight to ten feet from the back door.

A Word to Dad: Don't kick, scold or grumble—get in and help the boy—he's your boy.

Another Word to Ma: Make Dad screen the porches, doors and windows. If he won't get wire screen, make him get mosquito netting.

Flies Spread Disease

Typhoid fever, tuberculosis, summer complaint, cholera, intestinal diseases, and frequently death follow closely in the trail of the common house fly.

Thousands die every year from diseases carried by the fly, yet we still look upon it as an annoyance to be tolerated, not as a death-dealer which can be exterminated.

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PROCEEDINGS OF THE CLASS FORMED FOR THE STUDY OF THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

BUREAU OF ENTOMOLOGY
★ OCT 7 - 1918 ★
RECEIVED

July 15, 1918, 3:40 p.m.

The tenth session was held in room 411 Bieber Building, with the following in attendance: Back, Barber, Boving, Caudell, Dusham, Gahan, Greene, Heinrich, Hyslop, Kneale, Kotinsky, Mann, Middleton, Morrison, Perrine, Pierce, Reed, St.George, Snyder, Weigel, Whitcomb, Wood, 22 in all.

The secretary read the correspondence with H.Horning, City Entomologist of Philadelphia, Pa., pointing out the fact that Mr.Horning is the first and only City Entomologist in the country and emphasizing the fact that one of the objects of this Class and its Proceedings is to stimulate interest in the subject to the end that every city and community, that can afford it, establish an entomological service as Philadelphia has done.

The leader called attention to the assignment questions on pp.110 and 111, urging all to answer them to the best of their ability.

The Leader then read the second lecture on the Diseases Borne by Nonbiting Flies.

In the minutes of July 8, a statement of Doctor Pierce was omitted regarding the practical application of the study of climatic factors. He stated that a proper knowledge of the relation of climate to the length of the life of the seed tick of the North American Cattle Tick will determine the length of time a pasture must be kept clear of cattle in order to free it of ticks. The whole scheme of pasture rotation for eradication of ticks depends upon the accurate determination of climatic laws.

It has long been known that if the fall planting of wheat is delayed

until certain climatic conditions prevail, damage from army worms will be avoided. This demands an application of the law of effective temperatures of the army worm. The northward movement of Laphygma frugiperda is in direct relationship to the northward movement of the favorable mean temperature.

Similar applications will ultimately be made to many species.of insects.

J. Kotinsky,

Secretary.

July 22, 1918. Lecture 10. IMPORTANT PHASES IN THE LIFE HISTORY OF THE NONBITING FLIES.

W. Dwight Pierce.

In the preceding lectures we brought together an accumulation of evidence against the common flies that frequent our houses, which should convince any one of the absolute necessity of keeping flies from our food, our houses and our bodies. We can only hope to accomplish this object by becoming familiar at least with the more important features in the life history of the flies. From the study of the transmission of disease we may pick out for example a few points in the biology which need to be stressed, for instance feeding habits, regurgitation of food, excreta, breeding places, oviposition, flight, attraction to odor.

We are dealing in this lecture not only with the common house fly but also with most of the common flies which frequent our houses and are known as domestic flies. Of the common household flies only one, the biting stable fly, Stomoxys calcitrans, is omitted for future discussion.

The members of the class would do well to examine some book in which the different species are illustrated, so as to become familiar with the characteristic markings. It will then be a good plan to collect the various flies around the house and determine their species.

Fairly good illustrations of common household flies are given in the following references:

Howard, L.O. and Hutchison, R.H.,1915, House Flies,U.S.Dept.Agr. Farmers Bulletin 679.

Richardson, C.H.,1917, The Domestic Flies of New Jersey, New Jersey Agric.Exp.Sta.,bull.307.

The best illustrations of the flies are contained in Patton, W.S., and Cragg,F.W. (1913) (see p.140).

Tables to species of common flies and also illustrations are presented by Riley, and Johansen (1915) see p.140).

It is also desirable to know how to identify the fly larvae when found. The best American work on this subject is : Banks, Nathan ,1912, The Structure of Certain Dipterous Larvae with Particular Reference to those in Human Foods, U.S.Dept.Agr.Tech.bul.22. See also Riley and Johansen, p.315.

For general information on the life history, morphology, and anatomy of the house fly refer to: Hewitt, C.Gordon,1917, The House Fly, Cambridge University Press.

At a little later date Mr. Greene will present to the class a lecture on the differentiation of these flies and their larvae, with sketches which will be mimeographed. In this way we hope to make the identification of common flies easier for all of you.

The flies are classified largely on the charactersof the proboscis, antennae, wing veins, eyes and the arrangement of hairs. The larvae are classified on the characters of the spiracles, the cephalo-pharyngeal skeleton, tubercles, hairs and processes.

House Fly MUSCA DOMESTICA.

The common house fly, Musca domestica, is that insect charged with the greatest number of diseases, and probably justly because of its frequentation of all types of excreta, garbage and waste, its common visitations to places where foods are handled, and also its visits to the human body. We have shown in the preceding lectures how it and its allies can carry disease and what diseases are charged against each. Now we will take a brief review of its life history in order to arrive at important data for handling its control.

The house fly adult is yellowish to dark gray in color, with four equally broad longitudinal stripes on the thorax; first three abdominal segments yellowish with a central black stripe and with two less distinct discal stripes. The males measure 5.8 to 6.5 mm.in length, and the females 6.5 to 7.5 mm. The eyes in the male are nearly contiguous and in the female are widely separated.

This fly has been distributed by commerce to almost all parts of the civilized world.

Certain features of its anatomy are of interest in the present study.

The head is prolonged to form a proboscis which is enlarged at tip into the haustellum bearing apically the oral lobes or labella. These lobes bear a large number of channels kept open by incomplete chitinous rings called pseudotracheae, which are fully described by Graham-Smith in his text book (see p.140). The proboscis of the house fly is adapted to sucking and the absorption of liquid or liquified food., It cannot take up very large particles of solid food. Nicoll (1911) (see p.142), found that the flies could not ingest particles larger than .045 mm. This therefore determines the size of worm eggs which can be ingested by the adult. We must assume therefore that when flies contain larger eggs, these were taken in by the larva. Normally however the food must pass between the bifid extremities of the chitinous rings of the pseudotracheal channels and pass along these to the mouth. These openings measure from .003 to .004 mm. in diameter. Solid particles howeveb are heaped up in a slight ridge in the channel between the oral lobes and are probably sucked into the oral pit and into the mouth.

When the fly feeds on dry substances such as sugar, dried specks of

milk or sputum, etc., it first liquifies the substance by a salivary secretion which flows into the oral pit and onto the substance, being distributed by the pseudotracheal channels. The moistening is also aided by the regurgitation of food from the crop, as proven by Graham-Smith, who fed flies upon carmine colored food, and found carmine stains on semifluid material upon which these flies later fed, for 22 hours.

The intestinal canal is composed of pharynx, oesophagus, crop, proventriculus, ventriculus or chyle stomach, proximal and distal intestine and rectum. The oesophagus passes from the pharynx through the cervical region into the thorax in the anterior part of which it opens into the proventriculus, and from this same point a duct which is continuous with the oesophagus passes back into the abdomen to the crop which is a bilobed sac, capable of considerable distention. This crop serves as a food reservoir. The fly feeds until it has engorged the crop, and often will continue feeding, the food then passing directly into the proventriculus. The opening of the proventriculus into the oesaphagus is ventral. This organ is circular, flattened dorsoventrally. The ventriculus is tubular, narrowest in front and narrowing again in passing through the thoraco-abdominal foramen. The proximal intestine is the longest region of the gut, being considerably coiled. The distal intestine begins at the entrance of the Malpighian tubules, and is only curved once. It is separated from the rectum by a valve. The rectum is composed of three parts, the intermediate of which is swollen to form the rectal cavity into which the four rectal glands empty.

Food may remain in the crop for several days, and even when no further food is given, it requires many hours to empty the crop completely. After feeding the fly usually retires to a quiet spot and cleans its head and proboscis. It frequently regurgitates its food from the crop in the form of

large drops of liquid which are subsequently slowly drawn up again and probably pass into the proventriculus. These drops of regurgitated food frequently are deposited, often for the purpose of moistening sugar and similar dry foods.

We may now see how easy it is for a fly which has fed on infected substances to contaminate other substances for days by regurgitation from the crop, as well as through fecal deposits. Experimental evidence has proven contamination by both the feces and the vomit.

The fly's body is externally constructed so as to further aid in disease carriage. There are numerous hairs or setae on the body, especially on the legs. The last joint of the tarsus of each leg bears two claws and a pair of membranous pyriform pads or pulvilli. These pulvilli are covered beneath with innumerable, closely set, secreting hairs by means of which the fly is able to walk in any position on highly polished surfaces. These sucker-like pads or pulvilli and the setae of the legs are excellent bacteria carriers, and not infrequently larger organisms as mites, worm eggs, etc are thus carried.

The sexes of the house fly are about equal. Copulation may take place, according to Hutchison, as early as the day following emergence. Oviposition may begin on the third day. Mr. Hutchison (Notes on the Preoviposition Period of the House Fly, Musca domestica L., U.S.Dept.Agr.bul.345,Feb.1916) cites a large series of observations on the preoviposition period showing that eggs may be laid from 2½ to 23 days after emergence, and that the period corresponds to temperature and humidity changes. At Washington the shortest period was obtained at 82° to 84°F., and in general the length of period increased with the decrease of temperature. Increase in humidity seems to hasten egg laying.

The eggs are white, cylindrically oval, slightly broader at the posterior end with two distinct curved rib-like thickenings on the dorsal surface, along one of which the egg splits on hatching. These eggs are laid in masses averaging about 120, and a female may lay as many as four such patches, and probably under favorable conditions more. The eggs usually hatch in less than 24 hours, the time of course depending upon the climatic conditions. At 10°C. (40°F) the egg period is two or three days; at 15 to 20°C(59-68°F) it is 24 hours; at 25-35°C (77-95°F) only 8 to 12 hours, according to Hewitt.

The larvae are white, smooth, cylindrical maggots, tapering at the head end and considerably enlarged at the tail end. When viewed by transmitted light a dark chitinous structure can be seen in the anterior regions. This is called the cephalopharyngeal skeleton and is partially extrusible. Each species of fly is distinguishable by the form of this skeleton and hence if a slide mount is made of a skin boiled in potash, the species can be identified by this and one or more other characters. The three larval stages differ somewhat in the form of this skeleton so that it becomes possible to determine exactly the stage of development. The body is composed of thirteen segments of which the second is considered a fusion of prothorax and mesothorax. This segment at its posterior margin bears the anterior spiracles which are fan shaped and have six or seven lobes. This segment is followed by the mesothorax and nine abdominal segments. The anterior portion of the venter of the first eight abdominal segments bears spiniferous pads which assist in locomotion. The ninth or last segment bears the spiracular plates above and the anus below. These spiracular plates afford the best means of identification of fly larvae. In the first two stages each plate consists merely of two oblique slits on a slight prominence. In the third stage they

are well defined plates, D-shaped, closer together than their width, with flat faces opposed, each with three sinuous slits.

The larval period varies in response to climatic stimuli, but under favorable conditions is about four days in length. When full grown the larva varies from 10 to 12 mm. Pupation takes place within the last larval skin which shrinks and hardens to form a case or puparium. This period lasts from 3 to 10 days. When the fly is ready to emerge it pushes off the cap or head end. The entire developmental period may require from eight to eighteen or more days. Kisluik has found pupae of the fly in manure piles at various times during the winter, which of course indicates that the developmental period may occupy an entire winter if the pupa is caught by cold weather.

The adult flies are capable of considerable flight. Parker demonstrated a migration of two miles in his Montana studies. In this connection the most interesting contribution is that of S.C.Ball(1918, Migration of Insects to Rebecca Shoal Light Station and the Tortugas Islands, with special reference to mosquitoes and flies. Carnegie Inst.,Washington, Publ. 252) in which he shows that house flies apparently migrated with the wind from 46 to 95 miles.

The house fly has been found breeding in horse manure, human excrement, and hog manure very freely and to some extent in cow and chicken manure. It lays its eggs in a great variety of decaying animal and vegetable materials, such as slops, spent hops, moist bran,ensilage, rotting potatoes, dead animals, excreta-soiled straw, paunch contents of slaughtered animals, soiled paper and rags, etc.

THE BLUE BOTTLE FLIES OF THE GENUS CALLIPHORA.

The large blue bottle fly, Calliphora vomitoria and its near relative C. erythrocephala are often found in houses. These flies have also been shown to be dangerous insects because of their ability to transmit disease. In fact they are much more likely to directly transmit disease organisms than the house fly because of their habits of breeding in live flesh which gives them also the names blow flies. The adults are bluish black on the thorax and dark metallic blue on the abdomen. In vomitoria the genae are black and beset with golden red hairs, while in erythrocephala the genae are fulvous to golden yellow and beset with black hairs.

These flies are necrophagous and deposit their eggs upon any fresh, decaying or cooked meat, and upon dead insects; they breed in human excrement and will deposit their larvae in any open flesh wound. On the battle front where the wounded may lie for long periods and where many dead bodies remain uncared for, these flies have multiplied to tremendous numbers and are largely responsible for the carrying of infections to wounds. The subject of myiasis is to be discussed in a later lecture so we may pass over it at this time.

Important as they are the blow flies are usually subordinated to the house fly in the discussions of dangerous flies, but thorough investigations of these species are more than likely to greatly increase their standing as disease carriers.

The eggs are deposited in masses of as many as 300 to a batch, and a single fly may possibly deposit three batches. They hatch in from 10 to 20 hours after deposition.

The larvae of C. erythrocephala may be distinguished from the house fly

larvae by having usually nine but some times up to twelve lobes in the anterior spiracles; an anterior scabrous swollen ring on each segment of the abdomen, and a ventral groove on each segment beneath; stigmal field concave, surrounded by three pair of tubercles above, and two large and one small pair below; the stigmal plates about once and a fourth their diameter apart, each with three straight slits, directed principally toward the opposite plate; there is also an anal pair of tubercles. The larval characters are illustrated by Hewitt and also by Banks.

The larval period requires seven and a half to eight days at 23°C(73.5°F) and the pupal period fourteen days, according to Hewitt.

THE SHEEP MAGGOTS, OR GREEN BOTTLE FLIES.

The European sheep maggot fly, Lucilia caesar is primarily an outdoor fly but occasionally is found in doors, especially in farm and country houses. It is more brilliant than the Calliphoras, being of a burnished gold with a bluish green or shining green color. The flies are strongly attracted to meat and carcasses in which they lay their eggs. They also occur on human and animal excrement. The larvae breed readily in all these substances. In Europe the flies very commonly lay their eggs in matted wool and on the flesh on the backs of sheep, and the larvae breed in the flesh causing external myiasis.

These larvae measure 10 to 11 mm. in length and have not adequately been separated from Calliphora erythrocephala. The larval period averages about fourteen days and the pupal stage about the same.

Undoubtedly under battle front conditions this fly can be expected to visit human wounds and breed in them as readily as does Calliphora. It has been shown by Cao to transmit anthrax with equal ease.

Several other species of Lucilia have like habits, and the larvae of two

of these L. sericata and L. silvarum are described and illustrated by Banks.

The Lucilia sericata is the common American green bottle fly. It breeds in meat and animal refuse and is commonly found in dwellings. Its color ranges from brilliant bluish green to a dark metallic bronze green, and is without stripes or other markings. The larva has eight lobed anterior spiracles. The same number of tubercles margin the stigmal field behind as in Calliphora, but they are smaller and sharper. The stigmal plates are about one half their diameter apart, each with three straight slits, directed somewhat toward each other, but also downward. This species also attacks ulcers and sores of men and animals. Its most common attack on sheep and calves is made on the soiled rumps of animals suffering from diarrhea. No doubt the flies also serve as distributors of the diarrhea.

OTHER SCREW WORMS AND BLOW FLIES.

The question of myiasis, which covers screw worms and blow flies is to be considered in a separate lecture, but mention must be made of them at present because undoubtedly many infectious diseases are carried by these insects which attack alike live flesh through wounds and dead animals. I would hardly hesitate to claim that probably all such flies may carry anthrax at least, and probably do carry other diseases.

Bishopp, Mitchell and Parman (1917,Screw Worms and other maggots affecting animals, U.S.Dept.Agr.Farmers' Bull.857) describes quite fully the habits of the common American screw worm, Chrysomyia macellaria which breeds in both carcasses and flesh wounds. They also treat Phormia regina, the black blow fly, and other species. The large hairy blow fly, Cynomyia cadaverina and the gray flesh flies Sarcophaga texana, S. tuberosa

sarracenioides, and S. robusta are also treated.

Froggatt (1915,Sheep Maggot Flies,Dept.Agr.New South Wales,Farmers' Bull.95) has given a very fine treatment of the most important sheep maggot flies and has colored illustrations of some of them.

All of these flies are likely to be found in houses and markets and when given the opportunity will lay eggs on meat offered for sale or exposed in kitchens or mess halls. If this meat is already cooked, there is a good chance of the eggs being ingested and giving rise to gastrointestinal myiasis. But the danger from flesh flies is greater than the mere causation of external or internal myiasis. The flies which lay the eggs may have bred in diseased carcasses, and if so probably will deposit with the eggs a glutinous film containing bacteria from those carcasses, for it will be remembered that the fly larva takes up these bacteria and they may remain in its body until it as a mature fly lays its eggs,and even longer.

OTHER EXCREMENT BREEDERS.

Others of our house flies as the nonbiting stable fly, Muscina stabulans, the lesser house fly Fannia canicularis, and the latrine fly, F. scalaris breed in decaying vegetable and animal matter.

Muscina stabulans looks very much like the house fly but it is a little more robust. It is gray and the thorax is marked with four longitudinal black lines. The principal differential character is in the wing venation. The larva,however, is easily distinguished from Musca domestica, by the six lobed anterior spiracles and the anal stigmal plates scarcely elevated, less than their diameter apart, each with three very short slits pointing towards those of the opposite plate. It breeds in decaying and live vegetable matter, human and animal excreta, and has even been reared from insect puparia. It

breeds likewise in raw and cooked meat and on carcasses. It is therefore a very potential disease carrier, possessing all the opportunities of the house fly, with which it may already be mixed in medical literature.

Fannia canicularis and F. scalaris are two flies commonly found in houses, which greatly resemble the house fly, but the former may be distinguished by the presence of only three dark stripes on the thorax instead of the four found in the house fly. The larvae of these flies are very readily separated by the large number of processes on all the segments. The posterior spiracles are located on raised processes and are not plates as in the species mentioned above. In F. canicularis there are four lobes to the posterior spiracles and six finger like lobes to the anterior spiracles.

These flies breed in excrement, and all kinds of decaying vegetable matter and are often found in cases of intestinal myiasis.

Report 4.

CAMP SANITATION WITH SPECIAL REFERENCE TO
INSECT CONTROL AT CAMP DIX.

W.N.Hess, June 24,1918.

Camp Dix is located on a slight height of ground in Central New Jersey. It no doubt was chosen for an army camp with considerable forethought for it possesses an ideal drainage, the soil is sandy, which fact together with its natural slope, and the extensive system of surface ditches, permit no standing water on the grounds. An extensive underground sewer system disposes of the waste from the kitchens and latrines.

The entire sanitary conditions appear to be excellent. Everything is kept clean both outside and within the barracks, so there is little to attract insects and other insanitary agents.

So far as insects are concerned the season is only commencing. Captain Bristol and Captain Long of the Medical Department are taking every precaution to prevent their presence in any numbers in the camp.

Thus far there have been very few flies, yet it is probable that when warmer weather comes they will be more abundant. The good sanitary conditions of the camp very largely prevent them from breeding here. All garbage that would attract flies is stored in iron covered cans and removed daily. Horse manure and such filth, in which flies breed extensively, is removed daily and shipped in cars from the camp for fertilizer purposes. Disinfectants are used about the stables so there is comparatively little chance for flies to breed. The camp kitchens are kept in a very sanitary condition since they are inspected frequently by men from the Sanitary Department. Wire fly traps are provided for each table in the mess halls. They have been of little use thus far however.

Captain Bristol says there is no lice problem here, but every precaution is taken to prevent their entry into the camp. The drafted men are thoroughly examined when they arrive and whenever a man is found with lice on his body he is at once given the regulation oil bath which has proven very successful in ridding the men of these pests. A few cases have been found in the camp but they were soon exterminated.

The mosquitoes of New Jersey are world famous, but thus far they have given very little trouble. The barracks are all thoroughly screened so the men are not bothered by them at night. Although there is no standing water on the grounds one has to go but a mile or two to the south or east before he comes to swampy ground. Most of these areas have been well ditched so there is comparatively little standing water on them. Oil is being used on the swamps about the camp. On two especially warm nights at the south end of the camp and found the mosquitoes very abundant. I feel confident that with the approach of warmer weather they will present a serious problem here.

The entomological problems or a sanitary nature in this camp are enormous, but up to date Captain Bristol and his men have met them in an excellent manner.

Report 5.

REPORT ON TRIP TO EDGEWOOD ARSENAL,
EDGEWOOD, MARYLAND.

W.Dwight Pierce.

On July 16, 1918, at the request of Lieut.Woodward acting under instructions from Colonel Walker, Commandant, I visited Edgewood Arsenal to look over the manure disposal question.

The following observations were made of sanitary conditions in the camp. The sanitary officers immediately involved in control work are Major S.L.Chappell, Captain R.E.Irwin, Lieutenants B.T.McCormack and C.W.Fry.

The reservation contains several more or less isolated groups of buildings and quarters. Much contract work is under way and there are many civilian laborers and several contractor groups of stables. As is usual in camps in a transition condition, sanitary conditions are not yet at the optimum. The roads have been badly rutted and contain many mud holes and horse droppings are to be seen everywhere. It is hoped that when the contractors are gone these things can be remedied. In fact I should consider it advisable to have a detail look after the removal of these droppings from the streets each day.

The manure is collected from the stables daily and is hauled to certain incineration areas, where it is windrowed on a windrow of wood so as to give an under draft. This wood is set fire and the windrow burns for several days. For humid climates this is a good incineration method for manure but presupposes cheap wood. The garbage incinerator is on the edge of a bank and is formed of brick ovens with rail gratings on which the garbage is dropped. A hot fire under the garbage completely consumes it.

A tank of water beside the incinerator is kept hot by the fire below and is used for cleansing the garbage cans. Lye is used in the cleaning.

In the stable yards I noticed some places where overflowing water had created bad mud holes with rich flybreeding conditions. These are to be oiled immediately and the leak stopped.

Mosquito sanitation is done by ditching and oiling with knapsack sprayers. Anopheles are said to be present and the malaria organism has been recovered from one mosquito collected in the camp. In treatment of flowing water drip cans are used.

Major Chappell has drawn up plans for a building to be used as a delousing plant which will have undressing rooms, barbershop, baths, sterilizing room, and dressing room. Steam sterilization will be used to kill the lice.

Report 6.

July 17, 1918. REPORT OF FLY BREEDING IN AND AROUND WASHINGTON.

G.L. Garrison.

Complaints have been made of large numbers of flies in various parts of Washington. I was detailed to investigate some of these complaints.

July 9,1918. In Chevy Chase,Maryland, the flies were bad on Irving Street. In this section there is no sewerage system, cesspools being used, which extend slightly above the ground. These are in bad condition draining into a small brook nearby. Tin cans and other refuse are dumped here, and the thick swampy undergrowth makes conditions worse. A grocery store on Brookville Pike had refuse piled behind the store and manure in heaps around the stable. Flies were bad here. At a stable between Broad Branch Road and Brookville Pike the flies were thick around the manure pile. On Woodbine Lane flies were breeding in a large manure stack at a stable. At Roy's Dairy near the B. & O. R.R. the stable was fairly clean but flies were numerous and were found breeding in the manure back of the stable.

The garbage from this section is hauled away two or three times a week and fed to hogs by a colored man. Around these pens are ideal conditions for fly breeding.

July 17,1918. Complaints were received also from the downtown sections. At 221 B Street,S.W. next to a public restaurant the back yard was in an insanitary condition. Chickens are kept here and flies were found breeding in the small chicken house and also in a box under the roost.

In an alley between 12th and 13th Streets, extending south from

C Street S.W. there was a small stable and manure is piled in several large barrels outside of this stable in the alley. This manure was working with larvae. This alley is in bad shape.

At Center Market where flies are so bad, in the center court yard, I found a large garbage bin open. Flies were swarming everywhere and numerous larvae were collected around the bottom of the bin on the outside.

A stable at the corner of 12th and B Streets N.W. had a large bin of manure. The lid is off and the manure was working with larvae.

Note.

These facts have been called to the attention of the local health authorities. W.D.Pierce.

PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF PUBLIC HEALTH AND SANITATION.

July 22, 1918. 3:30 p.m.

The eleventh session was held in Doctor Hunter's room in the Bureau of Entomology in presence of the following: Baker, Barber, Boving, Brace, Craighead, Dusham, Greene, Heinrich, Hoffman, Hyslop, Kneale, Kotinsky, Mann, Middleton, Moles, Perrine, Pierce, Reed, St. George, Snyder, Speare, Swartzell, Wright, White, 24 in all.

The Secretary read the letter of July 16 from Prof. Glenn W. Herrick, a recipient of our Proceedings, stating that he has found these reports very valuable and should have regretted very much to have missed them.

Doctor Pierce exhibited photographs of the house fly and also distributed copies of the standard works on flies which were referred to in his lectures.

Mr. Kotinsky expressed the opinion that it might facilitate assimilation of the lectures to have them abstracted or briefed by a member of the class under assignment. Mr. St. George was requested by the leader to make such an abstract.

The Leader referred to the assignment regarding entomology sanitary conditions, stating that some reports had been received and that he had one in preparation on Washington, particularly Center Market.

The Leader then read his lecture entitled: Important Phases in the Life History of the Non Biting Flies.

Mr Snyder was called upon to report on Quantico which he had visited during the week and was requested to prepare his statement in writing.

Doctor Pierce spoke on his trip to Edgewood Arsenal.

Mr.Kotinsky concluded the session by reading to the class the statement in Science, July 19, on "Guarding Soldiers' Camps against Flies and Mosquitoes".

J. Kotinsky,

Secretary.

Report 7.

REPORT OF VISIT TO CAMP LEE.

W. Dwight Pierce.

On July 24, 1918, on an invitation conveyed through Lieutenant T.R.Kendall, I visited Camp Lee near Petersburg, Virginia. The Camp proper is located about three miles from town. In general the Camp is formed like a rough horseshoe, with headquarters behind the center and the ends farthest from town. The company stables are all located on the outside of the horseshoe. The septic tank is being constructed beyond the left end of the horseshoe. The garbage disposal plant, remount station and base hospital are some distance from the camp proper on the town side.

The Camp Surgeon is Lieut.Col.C.E.Fronk, whom I did not meet. I met the Assistant Camp Surgeon Major David N.W.Grant, Captain T.J.Duffield, who is in charge of mosquito work and drainage, Lieut.R.G.Church, of the Utilities Q.M.Detachment, in charge of water and sewage in camp, and Lieut. J.R.MacVay, Sanitary Inspector of the Replacement Camp.

The Camp has a regular printed book of sanitary regulations which are very minute in some respects, but it is possible that the lack of precision in orders regarding certain insect conditions may be partly responsible for some of the conditions on which I will report. These orders are very precise about the fly around the barracks and picket lines, but do not touch upon fly questions at the incinerators, manure loading platforms, garbage disposal plant, or in the sewerage system. Anti-mosquito regulations are lacking. There are no instructions regarding lice, bed bugs,roaches, etc.

I notice by the Camp Paper that a reward of $50 is offered to the

man who shall collect the most flies. I could show an enterprising private where to get myriads of flies on the camp grounds. The fly problem is very serious in this camp and is entirely due to the lack of proper oversight of certain bad fly breeding foci. In fact the fly is not taken very seriously except by a few men. Flies were present in all buildings especially the mess halls, some worse than others. Pyramid sticky fly papers are hung up in all rooms and are catching multitudes of flies. I saw raw meat being chopped for hamburger which was swarming with flies.

Inspection of barracks is very thorough and I was very much impressed with the results obtained by Lieut.MacVay. The unusual presence of flies in the barracks is due to causes outside of his jurisdiction. All waste is placed in screened enclosures with labels separating the cans for meat waste; grease waste; vegetable waste; coffee grounds; egg shells etc., bottles; cans.

The garbage and cans are hauled in closed cans to the garbage disposal plant. All cans are supposed to be perforated in the bottom but are not. At this plant was a long line of farmers with cans into which the garbage was dumped. They carry this away and feed to pigs. I did not learn of any supervision over the feeding of this garbage. The cans are cleaned with soap and a cleaning powder but go back covered with flies.

I suggested to the sergeant in charge that they be cleaned with some creosote compound. He was glad to have suggestions. The floors of the washing room were greasy and covered with flies. I suggested that these also be cleaned with creosote. The drippage is caught beneath on a cement platform which drains into the sewer. This is washed daily. There is no grease trap here. At the door where the cans are loaded into the wagons

the ground was soaked and very attractive to flies. I suggested oiling. Nearby is the dump for tin cans. Here a mountain of valuable tin is being wasted. These cans although punctured could hold enough water to breed multitudes of mosquitoes. A fire burns at one place on the dump where coffee grounds, eggshells, banana peels, melon rinds etc., are supposed to be burned. While the sergeant was elsewhere I saw fresh horse manure, piles of banana skins, eggshells, coffee grounds, and cakes dumped among the tin cans and swarming with flies. He has great difficulty to enforce proper dumping. A fire was ordered built over the offending material, and it was suggested that the cans be covered with earth. Over the bone cans the sergeant had placed several fly traps and had them full of flies but hadn't caught half. These cans are emptied every day but always stand in the same place. Fly larvae were crawling around on the ground about these cans. Suggestions were made for better handling here.

The remount station ships out from seven to nine carloads of manure each day. The stables and yards are cleaned every day but neither oil nor borax has been used very much. From the looks of the yards I should say that the soft ground is saturated with manure and must be breeding flies, although I did not have time to investigate. At the manure loading station the manure is dumped from a high platform into the cars. Much of it falls on the ground and is supposed to be gathered up and loaded. This however is carelessly done. For several hundred feet along two tracks there were accumulations of manure, and also under the platform and this manure was breeding many flies.

The sewers are badly constructed, with leaks at many joints and I understand this condition exists over the whole camp, so that frequently

the leakage causes a pipe to sink and form a trap. The sewer opens a very short distance from the barracks into a fast running stream but soon slows up. Less than one-half mile from the barracks I saw the worst menace to human health I have ever seen. This sewage bearing stream, some 20 feet wide was dammed and also blocked by a large barge and fecal matter had backed up for a distance of over 600 feet and to the depth of a foot actually measured. It was alive with myriads of fly larvae and was covered with flies. Here is the answer to the fly campaign in the camp. This condition has been reported several times I understand. If action is not soon taken it will back up to the very mouth of the sewer in a few days.

Below the dam the water was fairly clear except where the abundant obstructions had caught and held fecal matter. Undergrowth was cleared along this stream and trees cut but the trees were felled into the stream bed so that its flow was in many places obstructed. No attention had been given to this stream from a mosquito standpoint. Cattle were grazing along its banks.

The mosquito work is done by a detail of 60 negroes and Captain Duffield has no assistants to do scout work. Anopheles has been found. A large swamp area has been drained, but I saw many streams of flowing water which have not been touched by sanitary squads. Rank vegetation bordered the banks of the streams.

All cases of genito-urinal diseases are isolated at one end of the camp and it was noticeable that in this end of the camp the latrines had not been screened. This section is inspected by officers of the base hospital.

The bed bug has not given trouble in the barracks but is bad in the

officers quarters. Fumigation has not been very satisfactory because of the double walls and loose construction of the buildings so that the bugs are found on the outside of the building following fumigation. Captain Duffield says the only way he can figure on meeting this is by constructing a tarpaulin covering for an infected building and fumigating with cyanide.

An excellent septic tank to handle all sewage is being constructed under the direction of Lieut.Church, and troubles such as mentioned above will not occur again, although the fecal saturated bed of the stream may give trouble for some time after proper action is taken in removing the tremendous accumulation of feces.

In a few days it is expected to house 5000 men in stables with dirt floors which are urine soaked. These stables have been whitewashed and lime sprinkled on the floors, but they have not been sewpt clean of the manure around the edges. Two cots will be placed in each stall. I would rather sleep outdoors myself. These stables are not screened. The mess halls for these men are roofed but open on the sides and unscreened.

One interesting feature of the mess halls, pointed out by Lieut. MacVay, is the loose central board of each table, which can be removed so that all food which falls between the cracks can be cleaned out, as this has been found to be a favorite fly breeding place.

The camp water comes from the city water supply which is settled in two basins, alum treated in two other basins, filtered through sand, and then purified with chlorine. The city water works is under the able direction of Lieut.Kendall, a sanitary engineer who has specialised on water supply.

A glance at the organization chart shows that a very small portion of the work of the Camp Surgeon's Office is apportioned to the Sanitary end of the work in which we are most interested.

Sanitation around the Camp and in town is ably directed by the Public Health Service.

In considering the state of affairs, serious as it is, we must grant that it is not entirely the fault of the medical officers and may not be theirs at all. It may be entirely the fault of army system. I do not know that all of the matters I mention have been reported to the medical officers, but I do know positively that the worst conditions were reported. They have a very thorough system of reporting and the condition of affairs is known in Washington. The big trouble and one that I think active measures should be taken to remedy is: that the camp sanitation personnel becomes changed whenever the division goes overseas and a new personnel unfamiliar with the conditions has to be built up; that the medical corps has no regular detachment of intelligent white men to do the ditching, cleaning, etc., but if it has any detachment gets conscientious objectors or ignorant, backwood negroes, and has to depend on the Quartermasters Corps for special assignments in emergencies; and finally that the medical corps has no adequate authority. It can suggest and advise, inspect and report on sanitary measures, but the actual work of carrying out the suggestions must be done by order of the commanding officer of the unit concerned, and if this officer is not disposed, nothing can be done but report to a higher officer. Apparently the sewage-trouble at Camp Lee is due to inability to settle on the proper agency to do the work. Such things should not be. When it comes to health matters of as grave potentiality

as this, red tape must be broken. The sanitarians should have the right to dynamite the dam and move the excreta, widen the channel or do whatever may be necessary immediately upon discovery.

Army officers do not yet realize the importance of the fly - it is more than a carrier of typhoid and dysentery, it carries a multitude of serious diseases, and fly breeding must not be tolerated within the bounds of a camp.

SEARCH PROBLEMS.

Please answer as soon as possible. These problems are practical problems met every day by army sanitarians.

9. How can you exterminate the cockroach in a double walled, loosely boarded mess kitchen? As soon as poisoning is started they migrate. Draw your answers if possible from personal experience. If you have none, hunt up a cockroach infested kitchen and try an experiment. A satisfactory solution of this problem is badly needed. If without experience, answer from theoretical standpoint.

10. What is your experience in ridding dwellings of bed bugs? What would you do in case of a badly infected barracks with double walls and many cracks? A satisfactory solution is badly needed.

11. How can ants be kept from kitchens?

12. Outline a scheme for adequate entomological sanitation of an army camp.

13. If with a marching army as sanitary entomologist, what would you consider necessary to be done at each stop and how would you divide the responsibility for having it done?

14. Draw up a set of entomological regulations for an army camp on a permanent basis.

15. You are in charge of entomological sanitation in a newly built camp. A sanitary detail of 100 men is given you, none of whom know anything of sanitation. You have one month to prepare the camp for 20,000 troops. The contractors are about to leave. What will you do?

QUESTIONNAIRE.

1. Name in Full. _____

2. Place and date of birth. _____

3. College education, degrees, and dates. _____

_____

_____

4. Instructors in entomology. _____

_____

5. Experience in medical or sanitary entomology. _____

_____

6. Number of years of entomological work and where. _____

_____

7. Specialties. _____

_____

8. Preferences as to service. _____

9. Willingness to enter military service as entomologist here or abroad.

_____

10. Names of persons best qualified to vouch for your integrity, your ability, your training and qualifications.

_____

_____

11. Previous military training. _____

12. Present salary and position. _____

Please fill in and return immediately.

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Please fill in and return immediately.

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July 29, 1918. Lecture 11. INSECTS IN RELATION TO PACKING HOUSES.

E.W. Laake.

Before the meat packing establishments of the United States were placed under government inspection there was very little attention paid to insects and their control in such establishments unless there was a direct loss to the packer, and even then only such methods as were necessary to meet the immediate situation, rather than the requirements of permanent sanitation, were employed. During the first years following the institution of inspection by the Bureau of Animal Industry under the law of 1906, packing plants were remodeled or rebuilt according to government specifications, and conditions were vastly improved from a sanitary standpoint, although the insect question was not handled vigorously until during the past few years. The importance of safeguarding from contamination and infection the millions of tons of meats and meat products prepared by the numerous packing houses in the United States is indeed a task worthy of attention, especially during the present time of the world conflict when our products are so direly needed by us and our allies. The insects play as great a role by contamination or actual destruction of meats and meat products as they do in other branches of agricultural industries is easily demonstrated when one becomes familiar with the ravages of these pests in the numerous establishments in our country.

Flies are the principal cause of annoyance and loss around packing houses. The house fly is probably of first importance. It is especially troublesome around the loading docks, in sausage kitchens and in markets. The blow flies are often very abundant, especially in departments handling inedible materials. In this country the black blow fly (Phormia regina) is probably the most important. The green bottle flies (Lucilia sericata and L. caesar) rank second and in the southern half of the United States the screw worm fly (Chrysomyia macellaria) is the predominant species in the summer months. Others concerned are the blue bottle flies (Calliphora spp. and Cynomyia cadaverina), flesh flies (Sarcophaga spp.), Muscina stabulans, M.assimilis, Ophyra spp., Chrysomyza spp., and the skipper fly (Piophila casei). Hide and ham beetles, mostly of the family Dermestidae, are of local importance, especially as destructive to hides. The three common cockroaches are to be found, especially the American roach and the croton bug.

Associated with all the larger packing houses are large stock yards, horse and mule barns, rendering plants, and thickly populated districts, all of which are prolific insect breeding places. These furnish part of their millions of flies, with those produced on the premises of the packing plants themselves, to constantly attack the fresh products of the establishments. Sanitation throughout the establishments and premises under government inspection, and in railway cars and other vehicles used in transporting meats, is rigidly enforced, but government inspectors have no jurisdiction over sanitary matters beyond that, no matter how bad the existing conditions may be.

With efficient city health departments a great deal can be done in cooperative work with the sanitary work of the packing establishments, but this is not always possible and as a result the production of myriads of flies goes on constantly in the immediate neighborhood of the plants and the task of protecting meat products and controlling flies at packing houses becomes proportionately more perplexing. In our Southern States this is an all year round work due to the fact that our winters are rarely sufficiently severe to cause the death of the immature stages and during warm days numerous adults emerge and seek food and protection in the constantly heated tankage and blood dryingrooms or other favorable departments. Here they usually also find large stores of excellent breeding material and can develop to maturity in a comparatively short time during the winter months. The breeding of blow flies in large accumulations of tankage and blood in drying rooms, as it is found in many packing houses, may take place during the winter even in the more northern latitudes as there are many species of blow flies that are quite resistant to cold and have the advantage of many warm protected places during severe weather.

That flies are carriers of many different diseases is well known. The germ-laden flies can easily contaminate many different cured meat products which are sometimes consumed without being cooked, or contaminate fresh meat products with putrefactive non-pathogenic and pathogenic bacteria, in this way hastening decomposition, and rendering the meat unfit for food. There is also loss of much meat that is "blown" with eggs or damaged by skipper fly larvae.

Next to importance to flies in meat packing establishments are cockroaches. Although they are not as numerous as flies, they are plentiful in almost all establishments just as they are more or less plentiful in dwelling houses. The damage done by cockroaches is due not so much to what they actually consume, which is necessarily a small amount, but to losses of portions of food which are contaminated and rendered nauseous. The presence of roaches leaves a fetid odor, which is persistent, and foods so tainted are almost beyond redemption. This odor comes chiefly from a dark colored fluid excreted through the mouth of the insect and perhaps also from the scent glands occurring between certain segments on the bodies of both sexes from which an oily liquid of a disagreeable odor is secreted. Favorable conditions for cockroaches as found within packing houses where there is abundant food of all kinds, as well as good protection in the winter, and many good breeding places.

Skipper larvae and hide beetles are often found by the millionsin the bone storage houses, especially in stores of bones collected at large in the country to which pieces of dried muscular tissue and skin are attached. These insects are not so often found in the department of edible supplies of the packing plants as the packers are well aware of the damage done by them, especially in cured and dried products, and a constant watch is kept to prevent their appearance or to quickly exterminate them when they do appear in such departments.

INSECT BREEDING PLACES AND THEIR TREATMENT.

The importance of proper construction and arrangement of abattoirs and packing plants with a view to eliminating insect breeding places and protecting the food products from insect contamination can not be overestimated. In plants already in operation many bad fly breeding places can be permanently eliminated by construction work. For instance much future trouble can be avoided by constructing a concrete catch basin, paving docks, loading track and stock pens, providing adequate driers for bones, fertilizers, etc., and ample dry storage facilities for inedible products. Excellent breeding media of both vegetable and animal matter are almost constantly present and are often found in huge quantities in various places on the premises of establishments or on "dumps" near the plants. Too often these large accumulations are neglected for some cause or other and insects, especially flies, have ample time to develop and emerge by the millions and many such places, especially those not under government supervision,are constant producers of myriads of flies throughout the warmer seasons of the year.

The undigested food of cattle called paunch manure, and the contents of hog stomachs together with the horse manure and stable cleanings from the horse barns, partly blood-saturated sawdust from the meat coolers and sediment from catch basins saturated with bloody water are usually hauled to a general dumping ground. These dumps are thus rendered very attractive to house and blow flies and nearly all of this material is wet when it is dumped and must have a day or two of hot weather in order to dry sufficiently to burn well. If it remains as long as four days before burning, which is often the case during rainy weather, fly larvae have sufficient time to develop before the material becomes dry enough to be burned and migrate to a nearby place where they enter the ground and complete the life cycle.

For the destruction of paunch manure, etc. incinerators of various types are used by some packing plants and stock yards. At Omaha, Nebraska, the Stock Yards Company has erected a huge incinerator of a special type that contains sixteen large cells equipped with water pipes throughout. As the contents of some of the cells are slowly burning, the water pipes are heated and the hot circulating water dries the contents of the freshly filled cells which are later also slowly burned. The ashes and charred material are then removed, mixed with finely ground, dry sheep manure and sold for fertilizer. At least six men are constantly employed filling the cells and removing the charred contents and the returns realized from the fertilizer are said to be sufficient to pay for all labor and pay a reasonable amount of dividends on the investment of the incinerator plant which was erected at a cost of $40,000.

Other types of incinerators in use which are operated mostly by packing plants for the disposal of paunch manure and refuse of all kinds are single and double cell brick structures where everything is completely consumed and the ashes are used for fillers of various fertilizers. At Chicago one plant hauls all its paunch manure and refuse on railroad cars a short distance away to an incinerator made of a series of old discarded iron rails which slope from the top of the track embankment to the ground with con-

siderable air space below. Here a fire is constantly kept burning and consuming the manure, etc. piledon the rails above. Ashes filling the space below the rails are removed when necessary and are mixed with other fertilizers. At a few large plants the paunch manure is loaded daily on railroad cars and is shipped out two or three times a week to places in the country where the manure is sold to truck farmers. The trackage beneath the cars along the loading docks is paved with concrete to prevent full grown larvae from escaping from the loaded cars when they are held over several days. The paving extends well around and beyond the length of the cars and near the outer edge is provided with a narrow, deep gutter filled to half its depth with water where it is connected with the sewer. Thus can carry off the excess of water and traps the maggots as they endeavor to migrate to a place for pupation.

When treatment of infested dumps is necessary borax solution or crude oil is mostly used. Spent Fuller's earth, a waste product from oil and lard refineries at packing houses, is also used at some plants with fairly good results, if the earth is thoroughly mixed with the paunch manure, etc. or is used as a covering. Spent Fuller's earth, when it is discarded at the refineries contains about 8 per cent oil and acts as a larvicide besides being a repellent for several days. In experiments at a Dallas packing house a saturated solution of arsenic was also found to be very effective for killing larvae in paunch manure.

Many other breeding places of importance exist such as in the hog hair, tankage, blood cooking, and drying rooms, as mentioned before, in fertilizer buildings, and along fertilizer loading docks where pulverized tankage and blood and bone meal accumulate on the ground under the docks, and along car tracks where it becomes moistened by rain or by open sewage disposal lines, quite often found under such docks. Often the soil so covered with moist animalmatter is found to be heavily infested with blow fly larvae. Borax treatment for such infestations is very effective and must be repeated frequently as fresh material is always accumulating and is readily reinfested. Crude oil or fuller's earth applied heavily on such breeding places packs the soil down well and also renders it less attractive for flies for a much longer period. It has repeatedly been observed by the writer that where enough oil or fuller's earth had been applied there was no fly breeding going on. When the capacity of a packing plant is over taxed, or when labor is short, large stores of bones and hog hair do not get thoroughly dried in the hot air driers and these then become heavily infested with blow fly and skipper fly larvae. The same condition is also often found in storage houses containing bones, hair, blood, and tankage that have been thoroughly dried but again moistened by water leaking through a bad floor or bad roof above. To prevent fly breeding in any of this material it must be thoroughly dried and then stored in an absolutely dry place.

Another common source of fly production found at packing plants is under and around stick-water vats where the glue stock is manufactured. Steel and wooden vats are used for boiling stick-water and sooner or later these vats may become leaky or are heated to such an extent that the stick-water boils over and saturates the soil below. Prolific fly breeding then takes place. Borax solution or crude oil treatment for such infestations is very

effective. In the stock yards the hog pens are usually all paved and the manure etc. is washed into sewers leading to a nearby stream. In many instances the sewer outlet is not directly into the water and the manure is deposited in large quantities along the banks of streams where it becomes heavily infested with fly larvae which develop in the moist manure then migrating to dry places for pupation and emergence. The manure mixed with hay and straw from cattle pens is usually hauled to nearby dumping grounds and is there allowed to decompose or is occasionally burned over, but very seldom incinerated.

Cockroaches are found in the blood and tankage rooms, dressing rooms and other departments that are not under refrigeration. Modern steel and concrete construction has much to do with eliminating these insects. The use of steam and hot water in cleaning up the machinery, walls and floors of all the departments and rooms containing edible goods destroys most of them that come in during the night and do not return to their better protected hiding places in the departments of inedibles where there are also good breeding places. Where steam and hot water can not be used freely against roaches the dusting of sodium fluoride is very effective. About four pounds of sodium fluoride applied with a dust gun by the writer in a dry salt cellar and tankage drying room at a certain packing house killed over 5,000 roaches and thoroughly cleaned away the pest. A thorough inspection of these same departments months later revealed only a few roaches which probably came in from other departments of the plant that were not treated.

When skipper fly larvae are found in cured meats the products infested are trimmed and the storage rooms thoroughly cleaned, or if the infestation is severe the meat products are rendered for inedible purposes, the uninfested products removed and the storage rooms fumigated

PROTECTION AGAINST INSECTS.

That flies can be kept out of packing houses to such an extent that they are not objectionable is well demonstrated in some of the large plants at Kansas City, Missouri, Davenport,Iowa; Omaha, Nebraska; Milwaukee, Wisconsin, and Topeka, Kansas, which are completely and thoroughly screened and remain remarkably free from flies on the inside although flies are plentiful on the outside.

For the protection of meats against skippers it is necessary to screen closely with twenty mesh wire. It is also necessary to keep the store rooms darkened. The use of fly traps around packing plants is fully justified. Even though everything possible is done to eliminate breeding places on the premises great numbers of flies come from the surrounding district to the attractive conditions which are to be found around packing establishments. Our investigations have shown that flies quickly come to slaughter houses when liberated at nearly a mile distance. No doubt they often travel much farther to such establishments. Traps of various models are used extensively at packing plants and where traps are well handled great quantities of flies are captured. Accurate records kept by some plants show that as high

as 285 pounds of flies were captured in one week with 65 traps of the conical hoop type. This type is by far the most efficient all round fly trap of some twenty different kinds tested at packing plants.

The most attractive bait for blow flies is the mucous membrane which is freed from intestines after it has become sour. At packing plants this material is known as "gut slime" and when it becomes warm it ferments rapidly giving off a very obnoxious odor that is very attractive to blow flies. On account of its bad odor it cannot be used in departments of edible foods or on loading and shipping docks. Sugar or molasses, one part, to three parts of water, makes a very good bait especially for house flies. A cheap black molasses mixed with three parts of water and allowed to stand a day or two before it is used to bring it to fermentation is a very cheap and effective bait.

Fly paper used extensively in screened rooms catches practically all flies that have gained entrance through doors which are necessarily opened and closed where much trucking is done. Screening of some doorways which are constantly in use by in and outgoing trucks is not practicable as flies light on trucks and follow them through the doors, and soon congregate on the inside of such rooms or departments.

To exclude flies from entrances of such doorways a rapidly revolving ceiling fan or rotary blade fan operated at a high rate of speed has been found to expel flies very effectively. When they enter the air current which should be directed down and outwardly they are driven out through the entrance.

Where breeding places are reduced to a minimum, where the plant is well protected by thorough screening, and where flies are effectively trapped, there is very little loss of meat or meat products, and the plant is in a sanitary condition from an entomological standpoint.

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PROCEEDINGS OF THE CLASS FORMED TO STUDY
THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

Lecture 12. THE CONTROL OF THE HOUSE FLY AND RELATED FLIES.

W. Dwight Pierce.

August 5, 1918.

We have now come to one of the greatest problems in Medical entomology, The control of the treacherous flies that visit our homes but to bring sickness and death. In two lectures I have given in condensed form an abstract of the proofs of disease transmission by the house fly and other nonblood-sucking flies, and in another lesson sketched the life history of some of these flies. We may now take up in an orderly manner a plan of fly eradication. The anti-fly measures may be classed as repressive and palliative, and of course the first are the most important.

THE FLY MUST BE FOUGHT WHILE BREEDING AND BEFORE IT HAS A CHANCE TO SPREAD DISEASE. Many persons object to the antifly breeding measures because of cost, but no cost is too great if thereby we prevent epidemics and the loss of thousands of lives.

Inasmuch as we are dealing with the fly as an army, amunicipal, a rural and a home problem the subject will have to be handled topically.

REPRESSIVE MEASURES

Striking the source.

Manure: The house fly normally breeds in horse manure, but may also breed in the manure of other domestic animals. It is apparent that this then is the first and most difficult point to strike. Army discipline makes it possible, when the command isproperly educated to the importance of it, to control the manure problem more easily than under any other condition on a large scale. Army camps in this country are producing manure on the wholesale scale of trainloads a day. Instead of the manure of the horses being thinly scattered over great areas, it is concentrated in a relatively small area.

Conservation of the manure is of course the important thing if possible. Here is gathered together tons of most valuable fertilizer. It should be put fo use. Consequently there have arisen different methods of handling to bring about its utilization. Large army cantonments in progressive rural sections are able to farm out the manure or sell to contractors who ship it by the carload daily. Elsewhere the manure is built up into compact stacks by driving the wagons over the top to pack it down and patting the sides to make tham straight. In such cases the manure is treated with borax at the rate of 1 pound to 16 cubic feet, or 0.62 pounds per 8 bushels of manure. this will kill about 90 per cent of the larvae. Straw is scattered around the edges and oiled, then swept up every few days and burned. British authorities have claimed that creosote does not injure the manure but the ex-

perience of Hutchison and Cook has been that it does. Borax used in the proportions recommended above is harmless to the manure. A water extract of hellebore, prepared by adding 1/2 pound of powder of hellebore to 10 gallons of water, which after stirring is left for 24 hours, is effective at the rate of 10 pallons to every 8 bushels (10 cubic feet). Likewise a mixture of 1/2 pound of calcium cyanamid and 1/2 pound of acid phosphate to each bushel of manure gives a larvicidal action of 98 per cent. Unfortunately these last two remedies are not available at present.

Hutchison's maggot trap consisting of a large slatted wooden platform over a cement water filled basin is an excellent method of preserving relatively small quantities of manure and was proven practicable at the Maryland Agricultural College. The principle of this trap rests upon the discovery of the migration of the larvae from the stack before pupation. The larvae drown in the water which may be covered with a film of oil.

Various types of dark room storage of manure have been suggested. Another good method used in Panama, is to set fire to the manure pile and burn it down about a foot thus covering the entire pile with ash.

Daily broadcasting with a manure distributor is all right in dry sections.

Incineration. When manure cannot be sold, farmed out or stacked to prevent fly breeding, it must be burned. In dry sections the windrow incineration may be practiced. The teams drop their loads in great long windrows, the horses straddling the rows. These are spotted with oil and set afire. The wooden chimney windrow practiced at Edgewood Arsenal consists of a windrow of logs piled to form a horizontal chimney over which the manure is piled and then fire is set to the wood. The hillside incinerator devised by Doctor Mann at Quantico, Consisting principally of iron rails and chicken wire screen or gratings under which a fire is burning is practical for a small camp. The hammock incinerator, a woven wire hammock or two suspended over a fire will do as a temporary expedient for a small detachment on temporary duty. Furnace incinerators can reduce the manure to an ash and save whatever is of value in the ash.

Collection of manure must be made daily from all stables, picket lines and stable yards. The stable floors should be made hard by saturation with oil or mixing with other soils such as the yellow clay, and pipe clay mixture with oil used at Camp Meade. They should be daily swept clean after removal of all manure, and daily sprinkled with borax water or limed. Frequent treatment with some creosote compound is of value. Picket lines become soggy with urine and manure unless treated by digging up the soil and saturating with oil and then tamping hard. Stable yards become filled with manure. They should be swept or scraped daily and all manure removed. Carelessness will occur around the edges of the field unless the inspectors are vigilant.

Manure loading platforms need to be carefully watched. Manure is likely to accumulate under the platform and along the tracks and will most certainly breed flies.

At one place, I passed by a side track where certain grain companies unloaded straw and feed, using horse drawn wagons. The ground along these tracks was a thick mixture of rotting straw, grain and horse droppings. This was across the street from the city market where flies were swarming in the fish stalls especially.

Cities need to exercise special vigilance in the observance of regulations regarding livery and private stables. I can recall in many good sized cities seeing large piles of fly filled manure piled on the sidewalk in front of livery stables in the heart of the city. Manure in cities should be daily cleaned up and placed in fly tight boxes and frequently removed to the country. Even in our own city there is laxness in the observance of this rule.

Garbage: Needless to say it is necessary that garbage be kept in fly tight cans and that it be daily removed. The army method of building a screened box for holding the garbage cans is very good. Empty garbage cans are very attractive to flies. I have seen wagons full of empty cans which had been washed in lye water swarming with flies returning to camp. It is necessary to wash them in a creosote compound. When garbage is farmed out for feeding to pigs the farmers should be bound by contract not to take more than their pigs can consume in a day. The feeding pen should have a cement foundation so that it can easily be cleaned. The remains of the days feeding should be burned. Many army camps dispose of the garbage by incineration. Others sell to contractors for reclamation. Some parts of the garbage are not of value for feeding or reclamation and I have seen examples where the material was thrown on dumps and not burned. Great vigilance is necessary at all waste dumps to see that no fly breeding material is dumped anywhere except on incinerators.

Grease traps at kitchens and garbage can washing platforms are attractive places for fly breeding and should be kept treated with creosote compounds.

EXCRETA. The disposal of human excreta is a great problem in all communities, but becomes acute in army camps. In temporary camps where Latrines are necessary the excreta must be disposed of daily. There are various methods many of which have been discussed in the camp reports. The excreta may be saturated with oil, covered with straw and burned daily. They may be treated with lime or borax, or creosote, and buried, gradually filling the latrine. They may be removed daily, hauled to an incinerator and burned. When a sewage system is available the difficulties are less, but care must be exercised to maintain the sewers in good repair. If a man hole does not operate properly and sewage accumulates on the walls flies will breed there. If the main leaks and washes away the covering soil flies will breed on the seepage. I have actually seen these conditions in army camps, so know that they are points to be watched. At some point unless septic tanks are installed, the sewage will empty into a stream. The stream bed must be kept free of obstructions with straight banks. No trees, shrubs, grass or other obstacles must interfere with the steady flow of the sewage, for behind every branch, or root or weed, solid excreta will accumulate and flies will breed. In case excreta do accumulate in spite of all vigilance they should be oiled, burned off and moved on with



all expedition, immediately upon discovery.

Packing House Waste: Mr. Laake's able presentation of packing house problems in the lecture of last week covers the subject sufficiently.

CARCASSES. Bodies of animals offer great opportunities for the breeding of many species of flies and especially for the spread of disease. Carcasses should be removed as soon as possible after discovery, The best way to dispose of them is to burn them. If they cannot be burned they should be treated with quick lime and buried. On the battle field it is often impossible to burn or bury. Foreman and Graham-Smith have ably shown the value of coal tar creosote oil as a deodorizer, preventive of decomposition and fly destroyer in carcasses.

MISCELLANEOUS BREEDING PLACES. Factory waste, rotting vegetable matter, the accumulation of debris along shore lines, chicken yards, pig pens, alleys, streets which are not swept, gutters etc., furnish fly breeding places.

PALLIATIVE MEASURES.

In view of the fact that flies can come great distances, even over 50 miles as shown by Ball at Rebecca Shoal, the sanitarian is not always responsible for all the flies that visit the locality under his jurisdiction. There is therefore always the necessity of taking measures against the flies themselves although this is entirely secondary to the prevention of breeding.

Screening. All foods must be protected from flies because many of the flies which visit foods lay eggs therein. This is especially true of meats which are attacked by blow flies, and cheeses which are attacked by skippers. City markets should not expose meats for sale uncovered as the attraction to flies is too great. A well screened house will have the least trouble from flies. In army camps anywhere in the United States all sleeping quarters, kitchens and mess halls should be well screened against flies. All hotels throughout the country especially in rural communities should be required to screen all windows and doors.

The fly situation around small country hotels is by far the most repulsive that can ordinarily be found in any community. Very little, if any care is taken of the privies and the flies come directly from there to the kitchen and dining rooms.

Screening of garbage cans has been mentioned and is an admirable procedure. A Screened enclosure around privies and latrines would assist in keeping flies away.

Fly traps. Fly traps of many different designs have been devised. The most efficient is the cone and cylinder type devised by Bishopp. The Hodge window trap is good. A small cone and cylinder trap may be inserted in the lid of garbage cans. The principle of all efficient traps is the attraction of the flies by a good bait, and the arrangement of the trap so that once there the fly cannot get away. At all places where flies congregate, as markets, eating places, packing houses etc., the liberal use of good fly traps is a very good measure. As baits for such traps the

following suggestions have been made.

1. Beer, should be renewed every day or two.
2. Milk,
3. Overripe or fermenting bananas, crushed and placed in the bait pan.
4. Bananas and milk is better than either separately.
5. A mixture of 3 parts water, 1 part molasses, is good after it has fermented for a day or two.
6. A mixture of equal parts brown sugar and cheese or curd of sour milk, thoroughly moistened is good after it has been allowed to stand three or four days.
7. Mucous membrane from the lining of hogs intestines is attractive to blow flies and other meat infesting flies.
8. Ordinary fish and meat scraps.
9. Moistened garbage.

These baits are of little value if allowed to dry out. I have seen the fly traps in army camps standing out in the sun near the garbage cans, with no flies within but plenty of flies around, and the bait dried out by the sun. The fly trap must be more attractive than its surroundings.

Fly paper. Sticky fly paper has distinct merits and in the presence of abundance of flies should be used. The hanging pyramid strips are considered better by some army sanitarians than the flat papers.

Poisoned baits. Many fly poisons are on the market. Any kind of poisoned bait is dangerous in the presence of children or ignorant persons as there are many recorded fatalities to children from drinking fly liquids or licking poisoned papers.

Phelps and Stevenson (1917, Experimental Studies with muscicides and other fly destroying agencies: (Hygienic Lab, Bull. 108) have given a very thorough presentation of the question of fly poisons. Their bulletin should be consulted by any one desiring to go very far into this phase of the subject.

The most efficient strength of formaldehyde is 0.5 to 1 per cent, which is equivalent to 1.25 to 2.5 per cent of the 40 per cent solution sold as formalin.

A muscicide considered by them as even superior to formaldehyde in many ways is an aqueous solution of 1 per cent sodium salicylate plus 10 per cent brown sugar.

They used sodium arsenite as the basis for their experiments. This was made up in stock solution as follows:

Dissolve 4.95 grams pure sublimed arsenious oxide (As_2O_3) and 20 grams pure sodium cabonate in about 300 cc of distilled water by heating. When the solution was complete the liquid was cooled to 20° C. and the volume made up to 1000 cc. with distilled water. Ten cc. of the stock solution were diluted to 1000cc. with distilled water and this was called by them the standard arsenite solution, or one-thousandth normal solution.

Sodium fluoride solution, 1 per cent, gave a mortality equal to that of the standard arsenite solution.

An interesting feature of their investigation was the reduced effectiveness of these poisons with lowered temperatures.

Fly sprays. In the armies flies often congregate in tremendous numbers and some kind of spray is necessary to kill them. Maxwell-Lefroy handed me the following formula:

1 tablespoon formaldehyde.
1/2 pint lime water.
1/2 " water.

Kirk recommends as a spray in latrines, and tents, a light oil mixed with three or four parts water well shaken. Rubber tubing should not be used in the spray. A coarse atomizer such as is used in green houses is serviceable..

Bacot recommends a kerosene emulsion of 3 parts soft soap completely melted by heat in 15 parts of water and the addition up to 100 parts of kerosene or other light burning oil, and churning up to an emulsion. This may be kept indefinitely and diluted with water to about 1 part emulsion to 10 parts water content.

Protection of animals. Animals are seriously bothered by the pestering of flies. Any kind of netting that the animal can shake to disturb the flies is of some value. The question of repellents is one upon which many investigators have labored. Graybill (1914 Repellents for protecting animals from the attacks of flies, (U.S. Dept. Agr. Bul. 131) summarizes the results of these investigations. These formulas most in use all contain crude petroleum oil amd usually soap.

A good stock emulsion recommended by Graybill is made of:

Hard soap	1 pound
Soft water	1 gallon
Beaumont crude petroleum,	4 "

Dilute to 1 pate emulsion to 3 parts water.

Bishopp's fly repellent consists of:

Fish oil	1 gallon
Oil of tar	2 ounces.
Oil of pennyroyal	2 "
kerosene	1/2 pint.

For dairy cattle, Jensen makes a stock solution of crude petroleum with the addition of 4 ounces powdered naphthalin, and applies with a brush once or twice a week.

Jensen has also given three formulas of repellants for protecting wounds from flies.

Formula No. 1.

Oil of tar	8 ounces.
Cotton seed oil to make	32 ounces.

Formula No. 2.

Powdered naphthalin	2 ounces.
Hydrous wool fat	14 "

Mix into an ointment.

Formula No. 3.

Coal tar	12 ounces.
Carbon disulphid	4 "

Mix: Keep in a well stoppered bottle and apply with a brush.

It is of the utmost importance that flies be kept at a minimum in army camps. I canddo no better than cite a few authorities of the various armies in support of this. Ainsworth considers the presence of the house fly the greatest danger signal to an army in the field. Savas has called attention to the connection of flies with the great cholera outbreak in the Greek army. At Gallipoli the flies were in amazing numbers, the food was black with them as soon as it was set on the table. They filled the tents and shelters, settled on the refust of the camp, and on the unburied dead, and by their annoyance multiplied the sufferings of the wounded and spoiled the tempers of the hale. The flies have been very bad in France. Kirschner states that in the hospitals near the front the enormous number of flies presented a serious danger. Maxwell-Lefroy says that in Mesopotamia the tents and trenches were full of flies. The troops at Salonika suffered greatly from diarrhea and dysentery which coincided in appearance with the abundance of flies. Wenyon and O'Connor found flies in Egypt largely responsible for outbreaks of amoebic dysentery among the troops.

The fact that the flies are becoming bad in our camps should lead to very strenuous efforts on the part of sanitary officers even if diseases are not present which are known to be carried by them. The inoculation of our troops against typhoid fever must not be used as an argument against fly prevention, as I have had it advanced by sanitary officers recently. Such a fallacy may lead the nation into serious troubles.

BUREAU OF ENTOMOLOGY
OCT 7 - 1918
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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY

OF DISEASE, HYGIENE AND SANITATION.

Lecture 13, DISEASES TRANSMITTED BY MOSQUITOES.

August 19, 1918. W. Dwight Pierce.

The mosquitoes are the carriers of some of the most potentially dangerous diseases of armies, but we are considering them after the lice and flies because army mosquito sanitation has advanced so far beyond the measures of control against the other insects. To relax in control work against any of these dangerous insects might result in disaster.

Before taking up the habits and control of mosquitoes it is considered advisable to present to you a synopsis of mosquito transmission of disease. The matter may be difficult to assimilate, but may at lease serve as a ready reference. Some of you may find the making of a species catalogue will help to classify the matter presented in these lectures.

Probably more entomologists are familiar with the facts of mosquito transmission of disease than with any other phase of our subject, but it is necessary that we review the subject at this time in somewhat the same manner as we have handled the other problems of disease transmission.

In our study of the lice and non-bloodsucking flies we found that the disease transmission was principally through the feces, although in the flies also through the vomit, but never by direct inoculation. The mosquitoes present therefore an entirely new type of disease transmission, which we must now study. All known cases of disease transmission by mosquitoes are by direct inoculation at the time of the bite. In yellow fever and dengue fever the organism has not been demonstrated; in malaria of all types we have a known organism which undergoes a definite life cycle in the mosquito; in filariasis we also have the mosquito serving as an intermediate host for the early stages of the worm.

For complete studies of the life history of the malaria organism in the mosquito I would refer you to Hindle (Flies and Disease. Bloodsucking Flies 1914) in which you will also find lists of Anopheles of the world, with tables for identification, tables of malaria carriers and much more of a valuable nature, which should be carefully studied. Many other works deal very carefully with the subject however.

We may perhaps get a new conception of the relation of mosquitoes to parasitic organisms by arranging our discussion according to the classification, thus also enabling a comparison with the list of diseases carried by the non-bloodsucking flies. Those organisms which are parasitic only need to be listed in order that students take into account the possibility of confusing them with the pathogenic organisms being sought.

THALLOPHYTA: FUNGI.

Myxococcidium stegomyiae Parker, Beyer and Pothier (1903) is a yeast normal to the mosquito Aedes argenteus (Stegomyia calopus). It was thought by its describers to be the causative organism of yellow fever, but this was disproven by the work of subsequent authors. (Castellani and Chalmers p. 1005).

The mosquitoes have not been connected in any way with the carriage of bacteria.

DISEASES OF UNCERTAIN ORIGIN TRANSMITTED BY MOSQUITOES.

DENGUE FEVER, One of the severe fevers of the tropics, sometimes called break bone fever, occasionally occurs in the United States. It is undoubtedly caused by a living organism which requires over two days to increase so as to produce the symptoms of the disease when inoculated into human beings. It is so small that it will pass through the pores of a filter which will retain Micrococcus melitensis, which is only 0.4 micron in diameter. This minute organism is taken up by mosquitoes and transmitted to man. Graham-Smith and Ardate have observed small bodies in the red blood corpuscles, which are described as small, usually round, but sometimes elongate, bodies about one fifth to one third of the size of a red corpuscle. They divide up into minute granules, which become extra-corpuscular, and complete a cycle of schizogony. Graham-(1903) fed Culex quinquefasciatus (fatogans) on dingue patients and claimed to have found his organism in the mosquitoes up to the fifth day after feeding. He succeeded after an incubation period of four to six days, in infecting healthy people by the bites of mosquitoes fed on dengue patients in two series of experiments, claiming the transmission to be due to the Culex, but he states that Aedes argentus (Stegomyia fasciata) were present in many, if not all of his experiments. Ashburn and Craig (1907) in the Philippines also claimed to have proved transmission by the bite of the same mosquito, but Cleland and Bradley (1918) challenge the results of both these investigations. Nevertheless Bancroft (1906) conducted experiments obtaining two apparently successful cases of transmission of the disease by Aedes argenteus, ten and twelve days after these had bitten dengue patients, while in the failures the test patients were bitten fifteen, fifteen and seventeen days after the mosquitoes fed on individuals suffering from dengue.

Observations made by Legendre in Hanoi led him to suggest Stegomyia as probably a carrier of the virus.

Cleland and Bradley conducted extensive experiments with both Culex quinquefasciatus (fatigans) and Aedes argenteus (fasciata) and obtained positive results with the latter in four out of seven tests, and negative results with the former in two tests. The mosquitoes after biting dengue patients were conveyed to districts where dengue fever did not exist. The incubation period in man in these cases was from six to nine and a half days.

YELLOW FEVER. This dread scourge of the tropics is another mosquito borne disease of which the organism is not definitely known, although it is probably Protozoon. Seidelin in 1909, described a parasite belonging to the Babesiidae in the blood whd organs of yellow fever patients, as Paraplasma

flavigenum, which he considered to be the cause of yellow fever, but this organism is not generally accepted as the causative organism. There is undoubtedly an organism, for the incubation period in man is three days and the mosquito to become infected must bite a patient during the first three days of his illness, and then twelve days must elapse before the infected mosquito can transmit the disease.

The earliest suggestions of the possibility of mosquito carriage of yellow fever were made by Josiah C. Nott in 1888, and Dowler in 1855. In 1881 Dr. Carlos J. Finlay made definite claims that the fever is carried by the bite of a mosquito. In 1900 during the American occupation of Cuba a commission composed of W. T. Walter Reed, James Carroll, Aristides Agramonte, and Jesse W. Lazear began the investigation of the causation of yellow fever by first definitely discrediting the theory of the Italian bacteriologist Dr. Guiseppe Sanarelli, that his Bacillus icteroides was the cause. This they proved to be identical with Bacillus sui-pestifer. They then conferred with Dr. Finlay and began a thorough investigation of the mosquito transmission theory. Dr. Finlay suggested the common house mosquito, Aedes argenteus (Stegomyia fasciata) as the cause. The members of the commission submitted themselves to the making of the tests. Dr. Carroll was the first to take the fever, being bitten twelve days after a mosquito had bitten a yellow fever patient. In four days he took the fever. A week later Dr. Lazear while conducting experiments was bitten by a mosquito, which be allowed to engorge, but paid little attention to. In five days he took the fever and died in a week. In the course of experiments ten cases of fever were produced at will by the application of infected mosquitoes, and all other possible means of infection proved useless (see Reed etc.)

Dr. Guiteras (1901) confirmed the transmission of yellow fever by Aedes argenteus (Stegomyia fasciata) in seven cases, three of which proved fatal. Later a french commission, Marchoux, Salimbeni and Simond (1903) in Brazil and American commissions composed of Dr. Parker, Beyer and Pothier in Mexico (1903) and Drs. Rosenau, Parker, Francis and Beyer (1905), corroborated the transmission of the disease by this mosquito. The last named authors tabulate the whole series of transmission experiments showing that in 40 cases of transmission by mosquito bite the incubation period after the bite exceeded three days and a fraction, in only ten cases, and was possibly less than three whole days in only two cases. The maximum authentic record of the incubation period is six days and two hours.

The cirus of yellow fever may pass through the pores of a Pasteur Chamberlain B. filter. The disease can be conveyed by subcutaneous infection of the blood taken from the general circulation of a person sick with the disease during the first three days of the disease, but can be carried naturally only by the bite of a mosquito (Aedes argenteus usually called Stegomyia fasciata), that at least 12 days before has fed on the blood of a person sick with this disease, during the first three days of his illness. Phpohylaxis therefore consists in prevention of biting by mosquitoe and its extermination.

There is no definite proof that the virus can be transmitted hereditarily in the mosquito.

ANIMAL ORGANISMS TRANSMITTED BY MOSQUITOES.

PROTOZOA: MASTIGOPHORA: BINUCLEATA: HAEMOPROTEIDAE.

Haemoproteus danilewakyi (Grassi and Feletti 1890) cause of an avian anemia, passes its cycle of schizogony or sexual multiplication in sparrows, larks, ravens and birds of prey, and its cycle of sporogony or sexual multiplication in a species of culex. It occurs in Europe, Africa, India and America.

Haemoprpteus noctuae Celli and San Felice (1901) cause of avian anemia passes its cycle of schizogony in the owls, Glaucidium noctuae, Strix flammea, and Scops gin, and its cycle of sporogony in Culex pipiens Castellani and Chalmers (p. 295) give a detailed description of the life cycle as presented by Schaudiun, but in view of the fact that there is a belief that Chaudium has confused this species with a Trypanosoma we will omit discussion. It is supposed to occur in Europe, North Africa and America.

Haemoproteus syrnii Mauer (1910) Cause of an avian anemia, passes its cycle of schizogony in the wood owl, Syrnium aluco, and its sporogony in the mosquito Culiseta annulata.

PROTOZOA: MASTIGOPHORA: BINUCLEATA: LEUCOCYTOZOIDAE.

Leucocytozoon danilewskyi Ziemann (1898) cause of an avian anemia, passes its schizogony in the owls Glaucidium noctuae and Syrnium aluco, and its sporogony in the mosquito Culex rapiens, The mosquito sucks up from the blood of the bird the gametocytes or preliminary stages of the sexual forms. These are taken into the stomach of the mosquito. The microgametocytes or male forms escape from their capsules, and the nuclei break up into eight double chromosomes, which are reduced to eight simple chromosomes. These travel to the periphery and form the microgametes. The macrogametocytes develop into macrogametes. The gametes then conjugate and form the ookinetes, which are of three forms, male female and indifferent. These break up into very minute trypanosome-like bodies of the three forms which may divide by longitudinal fission. These are the forms which are inoculated into the owl by the bite of the mosquito. (See Castellani and Chalmers p. 303).

PROTOZOA: MASTIGOPHORA: BINUCLEATA: TRYPANOSOMIDAE:

A Trypanosoma sp. was recovered by Durham from Aedes argenteus (Stegomyia fasciata) which had fed on bats (Phyllostomus sp.), and another Trypanosoma was recovered from a Culex by Mathis .

Trypanosoma brucei Plimmer and Bradford (1899), the cause of NAGANA and JINJA, African animal diseases, is normally transmitted by species of Glossina, but Martin, Leboeuf and Roubaud (1908) successfully transmitted the disease from an infected to healthy cat by species of Mansonia.

Trypanosoma evansi (Steel 1885), the cause of SURRA in animals is normally carried by biting flies, especially the Tabanidae, but Mitzmain (1914) records experiments with mosquitoes in which the parasite lived 42 hours in Aedes argenteus (calopus) and 30 hours in Culex quinquefasciatus (fatigans), and C. [illegible]

lowi.

Trypanosoma gambiense Dutton (1902), the cause of GAMBIAN SLEEPING SICKNESS of man is normally carried by tsetse flies of the genus Glossina, but Roubaud and Lafont (1914) gave experimental evidence that it can be transmitted by Aedes argenteus (Stegomyia calopus). Heckenroth and Planchard (1913) succeeded in transmitting the disease by the bite of Mansonioides uniformis from guinea pig to guinea pig, when both were in the same cage, and also when not in contact, 24 hours after the mosquito had bitten the infected animal.

Trypanosoma noctuae Schaudiun (1904) which may be confused with Haemoproteus noctuae Celli and San Felice, mentioned above, passes its schizogany in the owl, Glaucidium noctuae, and its sporogony in the mosquito, Culex pipiens.

Trypanosoma rhodesiense Stephens and Fantham (1910), the cause of RHODESIAN SLEEPING SICKNESS, is normally carried by the tsetse flies of the genus Glossina, but Roubaud and La font (1914) have obtained experimental transmission with Aedes argenteus (Stegomyia calopus).

Trypanosoma ziemanni Schaudiun, another organism badly confused with T. noctuae and Leucocytozoon danilewskyi is recorded from Culex pipiens fed on the owl, Glaucidium noctuae,

PROTOZOA: MASTIGOPHORA: BINUCLEATA: LEPTOMONIDAE.

Crithidia fasciculata Leger (1902), a parasite of Anopheles maculipennis and Culex quinquefasciatus (fatigans). Laveran and Franchini (1914) record Leishmania from bodies, possibly of this, in mice infected from Anopheles maculipennis.

Leishmania Brasiliensis Vianna (1911), the cause of ulcers known as BOUBA or ORAL LEISHMANIASIS of man in Southern Brazil and Northern Paraguay is thought by Brumpt and Pedroso to be carried by Tabanidae or Culicidae.

Leishmania donovani (Laveran and Mesnil 1903) is the cause of INDIAN KALA AZAR: It has been proven that the bed bug can carry it, but the normal carrier is unproven. Franchini (1911) fed Anopheles near Clairiger on cultures of this organism and found that the parasite persisted and developed in the mosquitoes for at least 48 hours. Patton (1907) obtained no results in experiments with Culex quinquefasciatus (fatigans), Stegomyia ingens and Anopheles stephensi. Mackie (1915) also failed in his experiments with Culed and Anopheles.

Leishmania tropica (Wright 1903) is the cause of ORIENTAL SORE of man, which goes under various names, and it may really be a complex species. In investigating Bagdad sore Wenyon (1911a) fed Aedes argenteus (Stegomyia fasciata) on sores, and demonstrated in the mosquitoes the flagellate forms of the parasite up to 48 hours, but his transmission experiments failed. He later (1911b) succeeded in getting this mosquito to take up the parasites and demonstrated developmental stages in the gut. No evidence of infection could be found in experiments with Culex quinquefasciatus (fatigans).

Leptomonas algeriense Sergent and Sergent (1906) is parasitic in Culex pipiens and Aedes argenteus (calopus).

Leptomonas culicis (Novy, Mac Neal and Torry 1907) is native to the Culex pipiens and Culex quinquefasciatus (fatigans). Fantham and Porter (1915,1916) experimentally fatally infected birds, by feeding them on infected insects, proving it experimentally pathogenic to Passer domesticus and Chelidon urbica.

PROTOZOA: MASTIGOPHORA: BINUCLEATA: PLASMODIDAE.

The Plasmodiums are the causative organisms of malaria, which are all carried by the bite of mosquitoes. The cycle of schizogony occurrs in man, and of sporogony in the mosquito. This life cycle is very clearly set forth in many text books and should be studied carefully by all students. Briefly it takes place as follows; starting with the minute sporozoite inoculated in man by the mosquito. This sporozoite is an elongate sickle shaped body which bores into a red blood cell, and there forms an amoeboid shaped body known as the trophozoite, which gives off pseudopodia that absorb nourishment from the cell. At first this trophozoite is of uniform mass, but soon a vacuole is formed which causes it to assume a ring form. The trophozoite grows, withdraws its pseudopodia and becomds a schizont. This divides into many merozoites, which burst the cell and escape into the blood stream. This completes the cycle of schizogony which may begin again by the merozoite entering a red blood cell and becoming a trophozoite. On the other hand it may develop into a type of trophozoite which forms sexual bodies known as macrogametocytes and microgametocytes. These are the bodies, which when taken up by a mosquito, develop in the mosquitoes body through the cycle of sporogony, In the stomach of the mosquito the microgametocytes divide into many tiny elongate microgametes. The macrogametocytes change into macrogametes, and then conjugation of the gametes takes place. The resulting zygote is spherical, but it soon elongates into a small worm like body which is actively motile. It is then known as the ookinete. In this stage it bores into the epithelium of the gut wall and becomes rounded and thinly encysted. When encysted it is known as the oocyst. In this form it grows considerably in size and divides into sporoblasts, which divide into sporozoites. These tiny forms migrate into the salivary glands and are inoculated into a man at the time of a blood feast.

The species of human malaria are Plasmodium vivax Grassi and Feletti (1892) causing the tertian disease, Plasmodium malariae Laveran (1881), causing the quartan disease, and Laverania falciparum (Welch 1897) (also known as Laverania malariae Grassi and Feletti, 1890 or Plasmodium falciparum), causing subtertian, malignant tertian or aestivo-autumnal malaria.

Many species of mosquitoes of the group Anophelinae have been charged with carriage of malaria but in many cases the evidence does not show what species of organism is carried. The evidence is briefly summarized below (see also Hindle, pp. 96-107).

MALARIA OF UNKNOWN SPECIES: The following species of mosquitoes are recorded as carriers or thought to be carriers of some form of malaria. These anopheles are arranged in various subgenera, which are however omitted from our discussion.

A. Anopheles aitkeni James (fragilis Theobald) is suspected as a malaria carrier by Daniels and Christophers (Hindle p. 29).

A. Algeriensis Theobald was found by Sergent and sergent in Algeria to be a carrier in nature, the sporozoite stage being found.

A. apicimaculata Dyar and Knab has been suspected to be a carrier in Central America, but Darling records negative results.

A. arabiensis Patton was found in nature carrying sporozoites by Patton in Aden Hinterland (Hindls).

A. ardensis Theobald apprars to Castellani and Chalmers (p. 665) as a probable carrier of malaria in Natal.

A. boliviensis Theobald (lutzii Theobald) is suspected by Lutz to be a carrier in Brazil on what Knab (1913) considers insefficient grounds.

A. braziliensis Ghagas is cited by Brumpt (1913 p. 748) as a possible carrier of malaria in Brazil.

A. coustani Laveran of madagascar is listed as a malaria carrier by Castellani and Chalmers.

A. culicifacies sergentii Theobald of Algeria is listed as a malaria carrier by Castellani and Chalmers.

A. farauti Laveran is recorded as carrying malaria in the New Hebrides (Brumpt, p. 741).

A. Grabhamii Theobald of the West Indies and South America is listed by Castellani and Chalmers (p. 665). as a malaria character.

A. jamesii Theobald is listed by Castellani and Chalmers as a carrier of malaria (p. 665)

A. jeyporensis James is a carrier of malaria in India (Brumpt p. 745)

A. karwari James and Liston was suspected by Staunton as a carrier, but Christophers (1916) states that there is no evidence against it.

A. maculipes Theobald is cited by Brumpt as a possible carrier in Brazil.

A. martini Laveran is regarded on epidemiological grounds by Laveran as a malaria carrier in Cambodia. (Castellani and Chalmers, p. 665).

A. mauritianus Grandpre (Ziemanni Grünberg) is regarded by Ross as a doubtful carrier, not actively transmitting in Mauritius. Its synonym Ziemanni is recorded by Castellani and Chalmers as a carrier in Afraca.

A. mauritianus paludis Theobald is recorded as a carrier in West Africa by Castellani and Ghalmers.

A. minimus Theobald (febrifer) is according to Walker and Barber (1914) the most important mosquito concerned in the epidemology of malaria in the Philippines, being susceptible to infection and having a high avidity for blood.

A. minimus christophersi Theobald is accorded by Castellani and Chalmers as a carrier in India

A. nimba Theobald of Brazil is listed by Castellani and Chalmers as a carrier.

A. pitchfordi Tower of Africa is recorded as a probable carrier by Castellani and Chalmers.

A. punctulata Dönitz is listed as a carrier in New Guinea by Castellani and Chalmers.

A. pursati Laveran is considered by Laveran on epidemological evidence a carrier in Cambodia.

A. rhodesiensis d'thali Patton at Aden is cited as a possible carrier by Patton (Hindle).

A. sinensis pseudopictus Grassi is recorded by Castellani and Chalmers as a carrier in Italy.

A. turkhudi chaudoyei Theobald of Algeria is recorded by Castellani and Chalmers as a carrier.

A. turkhudi myzomyifacies Theobald was taken in nature carrying sporozoites of Plasmodium in Algeria by Sergent and Sergent (Hindle).

A. vincenti Laveran is recorded by Laveran as a carrier in Tonkin (Castellani and Chalmers).

A. willmori James of Tonkin, was taken by Mrs. Adie in nature carrying sporozoites of Plasmodium (Hindle).

Of above list we may consider therefore as proven malaria carriers Algeriensis, arabiensis, minimus, turkhudi myzomyifacies, and willmori. In the other cases the evidence is not sufficient.

SUBTERTIAN MALARIA: Caused by Laverania falciparum Welch 1897 (laverania malariae Grassi and Feletti 1890) This fever si also called tertian aestivo-autumnal and malignant tertian malaria. Records of transmission have been

made for the following mosquitoes.

Anopheles albimanus Wiedemann (albipes Theobald is the commonest carrier in Central and Tropical SouthaAmerica. Seventy per cent of those fed by Darling (1910) became infected, He traced development to the sporozoite stage.

A. annulipes Walker, a common Australian species has been shown by Kinoshita to carry this organism.

A. argyrotarsis Desviodyi is regarded as an undoubted carrier by Knab (1913) and Ludlow(1914) in the West Indies and South America. Although Darling found zygotes in nature, Hindle quietions the species of roganism.

A. barbirostria Van der Walp of India, Malaysia and China was recorded as carrier by Stephens and Christophers (Hindle).

A. costalis Loew was shown by Ross, Annetl and Austen (1900) to carry this organism in Tropical Africa.

A. crucians Wiedemann was definitely proven a carrier in Louisiana by King (1916) who found oocysts and sporozoites in his experimentally fed mosquitoes. He found 75 percent of his mosquitoes infected.

A. culicifacies Giles was shown by Stephens and Christophers to be the commonest Indian carrier.

A. formosaensis II Tsuzuki was found to be a carrier in Formosa by Tsuzuki (1902) who proved the presence of sporozoites.

A. fuliginosus Giles was shown to be the carrier in India by Stephens and Christophers who demonstrated zygotes in the mosquito.

A. funestus Giles is an active and important malaria carrier in Tropical Afraic, its connection with this organism being demonstrated by Daniela.

A. maculatus Theobald is a common carrier in India and the Malay States, its relation to this organism being shown by Staunton.

A. maculipalpis indiensis Theobald a common carrier in North West Terai, India was proven a carrierhby Stephens and Christophers who demonstrated zygotes.

A. maculipennis Meigen is the common malaria carrier in Europe, proven by many authors since Grassi.

A. minimus aconitus Dönitz and its synonyms albirostris Theobald, culigesus Dönitz and formosaensis I Tsuzuki has been shown to be a carrier of malaria in Malaysia and India. Staunton proved the carriage of this organism by albirostris and Tsuzuki by formosaensis I.

A. pseudopunctipennis Theobald (franciscanis McCracken) was proven a carrier in Panama by Darling (1910) who found zygotes in his experimental mosquitoes.

A. punctipennis Say was first proven a carrier of this organism in

Louisiana by King (1916) who found 20 percent of his experimental mosquitoes infected, and later mitzmain (1917) corroborated this by finding 27 percent of his experimental mosquitoes infected.

A. quadrimaculatus Say was first proven a carrier of this organism in the United States by Thayer (1900), and later corroborated by Woldert in 1901, and Hirshberg 1904, and finally by King (1916) who found 23 percent of his mosquitoes fed on a certain case infected.

A. rossii Giles was shown by Stephens and Christophers to be a carrier in India, but not commonly.

A. sinensis Wiedemann of Southeastern Asia was recorded as a carrier by Christophers (1916).

A. tarsimaculatus Goeldi was found by Darling (1910) in Panama to be infected in 100 percent of his experiments with this organism.

A. theobaldi Giles was shown to be a carrier in India by Stephens and Christophers who demonstrated zygotes in the experimental mosquitoes.

A. turkhudi Liston was shown to be a carrier in India by Stephens and Christophers who demonstrated zygotes in the experimental mosquitoes.

A. umbrosus Theobald was shown to be a carrier in the Malay States by Staunton, who demonstrated zygotes in the experimental mosquitoes.

For American students of aestivo-autumnal or Subtertian malaria the following species are therefore of importance -- albimanus, argyrotarsis, crucians, pseudopunctipennis, punctipennis, quadrimaculatus and tarsimaculatus. For those of our troops who go abroad the other species listed above are of greater importance.

QUARTAN MALARIA: This type of malaria is caused by Plasmodium malariae Laveran (1881). The following species of mosquitoes have been proven to be carriers:

Anopheles algeriensis Theobald was proven by Sergent and Sergent (1906) to be a carrier in Algeria.

A. costalis Loew was shown by Ross, Annett and Austen (1900) to be a carrier in Africa.

A. culicifacies Giles is the commonest Indian carrier and its relationship to this organism was proven by Stephens and Christophers.

A. fuliginosus Giles is not an active carrier in India but Stephens and Christophers demonstrated the zygotes of this organism.

A. funesta Giles is an active and important carrier in Africa, its role being proven by Ross, Annett and Austen (1900).

A. maculipennis Meigen is the common European carrier.

A. myzomyifacies Theobald is a carrier in Algeria according to Sergent

and Sergent(1906).

A. quadrimaculatus Say was proven a carrier in the United States by Beyer, Pothier, Bouret and Lemann (1902)

A. rossii Giles was proven capable of transmitting this organism in India by Stephens and Ghristophers.

A. sinensis Wiedemann was shown to be a carrier in China and Southeastern Asia by Tsuzuki.

A. stephensi Liston is claimed to be a carrier in India by Ghristophers (1916).

A. theobaldi Giles was proven a carrier in India by Stephens and Christophers, who demonstrates zygotes in experimental mosquitoes.

Thus it will be seen that only one species of mosquito is America, quadrimaculatus, has been demonstrated to be a carrier of quartan malaria.

TERTIAN MALARIA: Tertian malaria is caused by Plasmodium vivax Grassi and Feletti (1892). It has been shown to be carried in various parts of the world by the following mosquitoes.

Anopheles albimanus Wiedemann was hound to be a common carrier in Panama by Darling (1910), who demonstrated zygotes and sporozoites.

A. barbirostris Vander Wulp is recorded by Christophers (1916) as a carrier in India.

A. bifurcatus Linnaeus is recorded as a carrier in Europe by Grassi.

A. costalis Loew was shown by Ross, Arnett and Austen to be a carrier in Africa.

A. crucians Wiedemann was proven by Mitzmain (1916) to be capable of carrying this organism in Louisiana. Sporozoites were obtained.

A. culicifacies Giles is recorded as the commonest carrier in India by Stephens and Christophers.

A. fuliginosus Giles is recorded as a carrier in India by Christophers (1916).

A. funesta Giles is the most active and important common carrier in Africa according to Ross, Annett and Austen.

A. intermedium Chagas is a carrier in Brazil according to Cruz.

A. jesoensis Tsuzuki is recorded as a carrier by Christophers (1916).

A. listoni Liston is an active and important carrier in certain terai tracts in India, recorded by Kinoshita.

A. maculatus Theobald is recorded as a carrier in India by Christophers (1916).

A. maculipalpis Giles is recorded as a carrier in Asia by Christophers (1916)

A. maculipennis Meigen is a common carrier in Europe.

A. mediopunctatus Theobald is a carrier in Brazil according to Cruz (1910).

A. minimus Theobald is recorded as a carrier in India by Christophers (1916).

A. pharoensis Theobald is recorded as a carrier in Egypt by Newstead, Dutton and Todd (1907).

A. pseudomaculipes Ghagas is recorded as a carrier in Brazil by Cruz (1910).

A. punctipennis Say was first proven a carrier in the United States by King (1916). Sporozoites were found. Later Mitzmain (1916) corroborated this record.

A. quadrimaculatus Say was first proven a carrier in the United States by Thayer (1900), this was subsequently proven by other authors, including King (1916).

A. rossii Giles is recorded as a carrier in India by Ghristophers (1916).

A. sinensis Wiedemann is recorded as a carrier by Kinoshita in China.

A. stephensi Liston is recorded as a carrier in India by Loston and by Bentley.

A. superpictus Grassi is recorded as a carrier in Europe by Grassi and by Bignann and Bastianelli.

A. theobaldi Giles is recorded as a carrier in India by Ghristiphers (1916).

A. turkhudi Liston is recorded as a carrier in India by Christophers (1916).

A. turkhudi hispaniola Theobald is a common carrier in Algeria and Southern Spain according to Sergent and Sergent.

Thus we find tertian malaria in America carried by albimanus, crucians, intermedium, mediopunctatus, pseudomacuipes, punctipennis, and quadrimaculatus, three of which species occurs in the United States.

AVIAN MALARIA: Several forms of avian malaria are known.

Plasmodium danilewskyi Grassi and Feletti (1890) a malaria of sparrows, partridges, finches and crows is carried by Culex quinquefasciatus (fatigans) C. pipiens, C. nemorosus and Aedes argenteus (calopus) according to

Plasmodium relictum a malaria of the canary was proven by Sergent and Sergent (1918) to be carried by Culex pipiens.

PROTOZOA: MASTIGOPHORA: SPIROCHAETACEA: SPIROCHAETIDAE.

Spiroschaudinnia culicis Jaffe (1907) was found by Jaffe in the gut and malpighian tubules of Culex pipiens and Anopheles maculipennis.

METAZOA: PLATYHELMIA: TREMATODA: FASCIOLIDAE.

A Clinostomum is recorded by Soparkar (1918) which passes its first stage in a snail, Planorbis exustus, and is found as a cercaria in the larvae and adults of Culex quinquefasciatus (fatigans) and Anopheles rossi. Fish swallowing the mosquito larvae take up the worm which continues its development toward maturity. The final host is not known.

METAZOA: NEMATHELMINTHES: NEMATODA: FILARIIDAE.

Acanthocheilonema perstans Manson (1891), the cause of a form of human FILARIASIS in Africa is carried by biting flies. Hodges in Uganda obtained an incomplete cycle in Mansonicides africanus, Aedes argenteus (calopus), A. sugens, Anopheles costalis, and a Culex, and negative results with a long series of mosquitoes (Dye 1905).

Dirofilaria immitis (Leidy 1856), cause of CANINE FILARIASIS has been proven by Noe, Dye, (1908) Grassi, and Fülleborn (1912) to pass its intermediate stages in the following mosquitoes,-- Anopheles maculipennis, A. algeriensis, A. bifurcatus, A. sinensis (pseudopictus), A. superpicta, A. claviger, Culex quinquefasciatus (fatigans), C. malariae, C. penicillaris, and C. vexans, exceptionally in C. pipiens, and with difficulty in Aedes argenteus (Stegomyia calopus). The microfilaria or embryo worms are taken up by the mosquito with the blood of the dog. They soon pass from the stomach into the malpighian tubules. In ten days their development is complete and they migrate towards the head and into the proboscis. When an infected mosquito containing filariae in its proboscis feeds on a dog, the worms escape by boring through a delicate membrane, which unites the labellae, and thus they get on the surface of the skin. If this is sufficiently moist they penetrate the epidermis and may be found in the subcutaneous tissues, whence they work toward the heart and great vessels of the dog and there develop into adults.

Dirofilaria repens Railliet and Henry (1911) cause of SUBCUTANEOUS CANINE FILARIASIS passes its intermediate stages in the mosquito Aedes argenteus, its development having been demonstrated by Bernard and Bauche (1913). Its life history is quite similar to that of D. immitis.

Filaria bancrofti Cobbold (1877), the cause of HUMAN FILARIASIS or ELEPHANTIASIS, passes its intermediate stages in the mosquitoes, Complete development has been demonstrated in Anopheles rossi in India by James; A. costalis is West Africa by Annett, Dutton and Elliot; Culex pipiens in China by Manson; C. quinquefasciatus (fatigans, ciliaris, nigrithorax) in China by Manson, in Australia by Bancroft, in the West Indies by Lebredo (under the name pipiens) and also by Law, in the Philippines by Ashburn and Craig, and in India by Cruikshank and Wright ; Aedes pseudoscutellaris in Fiji; Mansonioides africanus by Daniels in Nyasaland; M. uniformis; Aedes argenteus (Stegomyia calopus, A. fasciata, Culex taeniatus) in Nigeria by Daniels, and in the West

Indies by Law; and Culex skusei in Australia by Bancroft.

Complete development has not been demonstrated as forms have not been actually seen in the proboscis, although advanced stages have been recorded in Anopheles sinensis (minutus, pseudopictus, peditaeniatus, nigerrimus) and barbirostris in Malaysia by Leicester; A. argyrotarsis in West Indies by Law; A. albimanus (albipes) in West Indies by Vincent; Mansonia annulipes (musivus) in Malaysia by Leicester,and in Australia by Bancroft; M. pseudotitillons; Culex microannulatus; C. gelidus and C. sitiens, A. perplexa, A. scutellaris, Scutomyia albolineata and Taeniorhynchus domesticus in Malaysia by Leicester.

The embryo microfilaria enter the mosquitoe's stomach with the blood. They rupture the sheaths which contain them pierce the walls of the stomach and find their way to the muscles of the thorax, where they develop. They finally work into the proboscis and escape during the act of feeding through Dutton's membrane as worked out by Lebredo (1905). They enter the skin through the bites or through pores.

Filaria demarquayi Manson (1897), another cause of HUMAN FILARIASIS was found by Fülleborn to pass its immature stages in the thoracic miscles of Aedes argenteus (calopus). Mense also records Culex quinquefasciatus and Anopheles albimanus as hosts.

METAZOA: NEMATHELMINTHES: NEMATODA: MERMITHIDAE:

Agamomermis culicis Stiles (1903) is recorded from Culex sollicitans in the United States.

From a purely American standpoint we must guard against mosquitoes as carriers of malaria, yellow fever, dengue, and filariasis, but troops operating in Mediterranean continues would also have to consider possible transmission of tropical sores amd Kala Azar. In South America other forms of sores; in Africa sleeping sicknesses may be carried by mosqutioes.

The burden of all this evidence is that mosquitoes should not be permitted to breed near human habitations, and especially near Army establishments.

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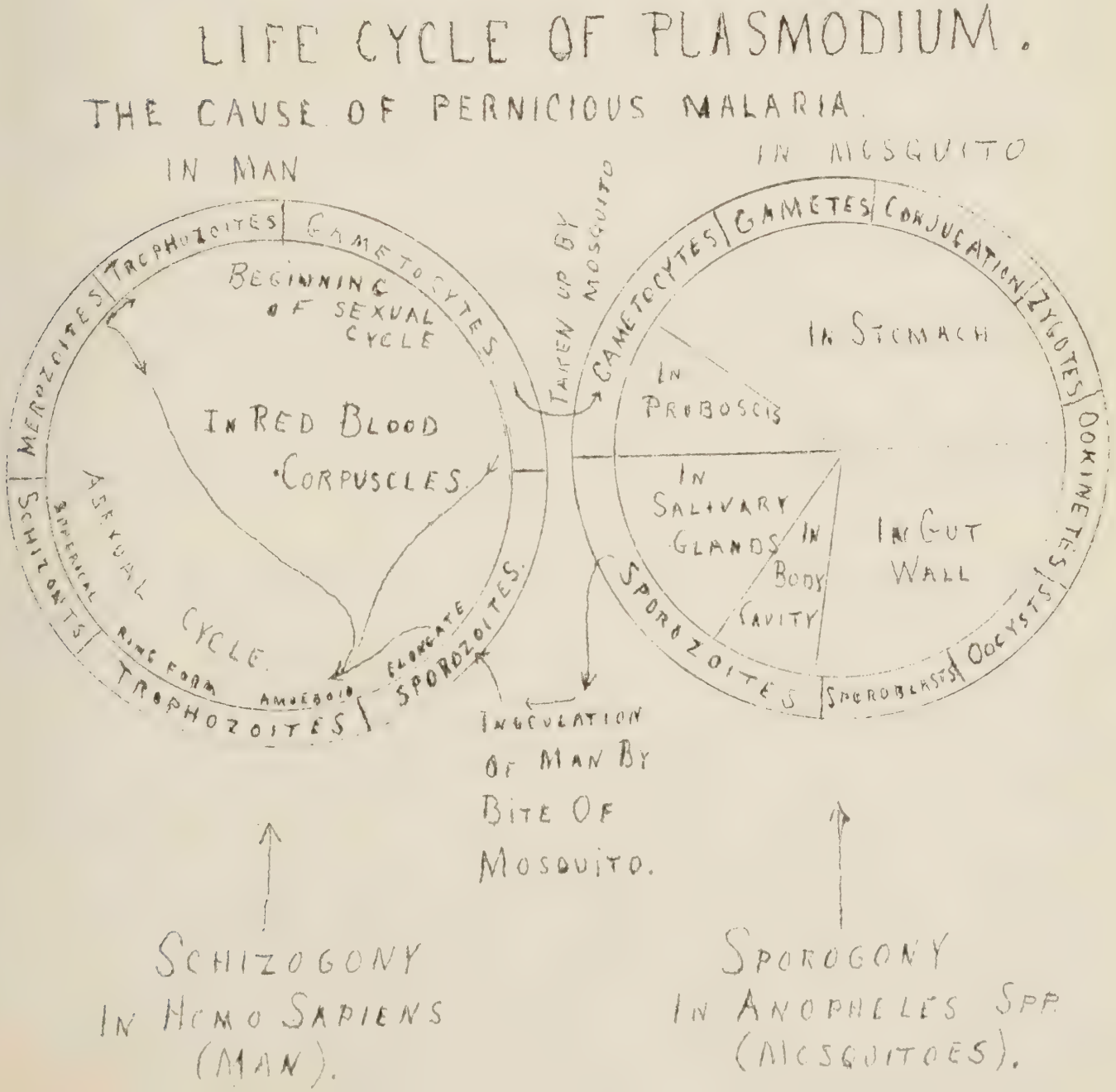
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CORRECTION TO REPORT ON CAMP DIX.

Captain C.L. Siebert is in charge of the Sanitary work at Camp Dix.



BUREAU OF ENTOMOLOGY
★ OCT 7 1918 ★
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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

Lecture 14, September 9, 1918.

CONTROL OF FLIES IN BARN YARDS, PIG PENS AND CHICKEN YARDS.

By

F.C. Bishopp.

The question of the control of flies in their various breeding media or places of breeding can not be well divided in the discussion. Attention has been given in a previous lecture to the general aspects of house fly control and the most favorable breeding media and methods of handling them have been discussed in a general way. Therefore I shall take up the special problems under the three situations listed in the title. Adequate care of the manure and other refuse in these situations will not only result in the prevention of breeding of house flies in them but will also reduce the number of certain other flies which play a part in disease dissemination among man and animals, notably the horn fly, stable fly, Muscina spp., Fannia spp., certain Sarcophagids and lesser numbers of Muscidae known as blow flies which occasionally breed in hog manure and freely in unconsumed animal matter in garbage.

Repression of flies in barn yard: The discussion of this problem is bound up closely with that of the control of the house fly through the care of horse manure, etc. If manure is promptly disposed of as removed from the barn the yards are kept in better condition and the scattered droppings either of horses or cattle are less dangerous as regards fly breeding. In drier regions of the country these droppings may be practically neglected. Where large numbers of horses are kept in sheds or yards the entire area requires treatment. The manure should be scraped up at least as frequently as three-day intervals and scattered thinly on fields or composted and treated with borax or other larvicide.

In large stock concentrating points where stock yards and mule sales stables are of great extent the problem of disposing of the manure from the yards is a difficult one. In the Eastern States it has been the usual practice to contract the manure to certain companies or to permit farmers and truckers to enter the yards and get manure when they desire it. One difficulty has been that stock are often kept in a single pen for feeding for some time and during this time it has not been the rule to clean up the pen. The provision of ample room so that stock may be removed from one pen to another to permit cleaning is important. This also applies to horse and mule sales stables. The restrictions placed upon the horse and mule dealers who expect to handle stock for the Army have tended to greatly improve fly breeding conditions in these stables and yards. I ahve frequently observed these sales stables to be filled with tightly packed manure from eighteen inches to three feet deep. In the case of an East St. Louis mule sales stable where one company has thirty-five acres under cover the removal of all of this manure was an enormous task. Yet it was accomplished so that the company might continue handling stock for government use. The manure was hauled several miles to a fertilizer plant where the well decayed

part was piled and subsequently dried, ground and sold as sheep manure for lawn dressings, while the parts with considerable straw were thrown from cars onto rail incinerators and burned, the ash being used in fertilizer mixtures. The entire barns and fences were then gone over with a machine which cleaned them of all accumulation of dust and saliva which had in some cases become quite thick and highly glazed. An effort is being made by the authorities in charge to have the manure from these stables throughout the country moved at weekly intervals.

It appears that where shavings are used for bedding less trouble arises from fly breeding than where straw is utilized. This would undoubtedly favor reduction in the breeding of Stomoxys also.

Returning to the question of handling manure in cow lots and small barn lots, it is advisable when labor is at hand, especially in dairy yards, to pick up the droppings daily or even twice a day. This is greatly facilitated by having the yard where cattle congregate in greatest numbers concreted. In large dairy lots it has been found feasible to bring the manure together by means of an iron road drag. This leaves the manure in windrows so it can be easily shoveled into a wagon.

For the disposal of manure from dairies and even on the farm no method is better than the use of a manure spreader and the scattering of the material directly onto the ground. Of course in cases where all land is cropped it is not convenient to employ this method during certain parts of the year although it is usually possible to have one portion of the farm available for manuring at all times.

The use of manure pits and boxes has been mentioned in a previous lecture, as has also the Hutchison maggot trap. It appears to the writer that any attempt to construct pits or boxes which are so tight as to prevent the escape of newly emerged flies is likely to meet with failure. In practically all instances the manure is infested more or less when placed in the box or pit and following this suggestion the author has been advocating the placing of the manure in boxes or pits which will not allow flies to gain entrance from the outside and which are provided with a cone or tent trap to capture the flies which breed out. In the absence of the trap feature these would almost surely escape to the light from the most tightly constructed box or pit which it is feasible to build and maintain. A manure box of this type has been tried by the Dallas laboratory and found to work admirably. The number of flies caught is often surprisingly large.

For small pastures and meadows it is sometimes feasible to utilize a brush drag to break up the cow droppings. This serves three purposes - preventing the breeding of the horn fly, scattering the manure evenly over the ground, and permitting the grass to grow where it would otherwise be prevented by the piles.

While the house fly does not breed readily in pure cow manure the writer has reared the species from this substance and has also found that where cow manure is mixed with a certain amount of straw it is a fairly good breeding medium for this species. The horn fly, Haematobia irritans, breeds exclusively in cow droppings either in large piles or individual droppings. Blow flies. are not known to breed in cow manure but a number of species of Sarcophagids,

most of which, however, do not have scavenger habits, breed in considerable numbers. The brilliant green fly, Pseudopyrellia cornicina, is very commonly seen on fresh cow droppings; in fact this is usually the most abundant species in this situation in the country. It may be readily mistaken for Lucilia when not examined carefully. This species is of no importance as a disease carrier as it doesn't enter houses or visit food.

In preventing flies breeding in yards it is very essential that water troughs be kept running over and whenever overflows or leaks do occur they shoul be fixed promptly and the moistened manure and earth cleaned up and hauled away immediately. Special attention should be given also to accumulations of horse manure in yards along feeding racks. Here the mixture of horse manure, waste hay and urine forms a satisfactory mixture for fly production.

The use of larvicides and other chemical compounds in barn yards is usually inadvisable. Through cleaning ordinarily will handle the situation. Crude oil has been used in yards where considerable numbers of horses are kept to permit firm packing of the ground and keep down dust in dry weather. Borax, either dry or in solution may be used in breeding places which can not be cleaned thoroughly. Poultry and hogs consume large numbers of larvae and pupae and scatter the manure so it will dry out rapidly. The agencies should not be depended upon, however, to effect control.

The employment of conical fly traps about stables and dairy barns will aid in reducing the number of house flies if they are kept properly baited. Sour milk or milk curd, brown sugar and water in equal parts form good baits. The latter if kept moist will remain attractive for two or three weeks. It is comparatively unattractive the first few days. Hodge type window traps aid in reddcing the house fly and stable fly troubles within barns if the barns are closely built and the other windows darkened or screened

Fly control in pig lots and pens: The hog has been looked upon from time immemorial as a filthy animal and he is usually compelled to live in surroundings which would never be tolerated for any other beast.

One of the special problems which confronts the Army sanitarian is the utilization on a large scale of the camp garbage by hog feeders. There appears to be no more economical way of disposing of garbage than by this method, but the conditions under which the feeding is to be done must be given strict attention by sanitarians. In the vicinity of nearly every large army camp is located one or more of these garbage feeding plants, the number of hogs ranging from a few hundred to several thousand. For the most part the garbage is sold to feeders under annual contract. It is sorted to some extent by the army kitchens. It is supposed to be free from glass, cans, coffee grounds, and liquids. The contractors furnish the garbage cans, remove the garbage daily and return empty cans which are supposed to be thoroughly cleaned. If the orange, grape fruit, and lemon peels could be eliminated from the garbage the mass of material not eaten by the hogs would be materially reduced. The writer is wondering if some use could not be made of these citrus peels for food, oils or otherwise.

Garbage feeding plants should be operated under approximately the following set of rules:

1. Location of feeding stations: Station should be located as far from habitations as possible and also well removed - two miles or more -

From army camps. Of course in this 207nnection

from army camps. Of course in this connection consideration should be given to the public in general as well as the army camps. Our recent experiments show that flies of various species, including the house fly, travel five mfive miles or more under rural conditions, but that there is rapid decline in the number of flies which reach points two miles or more from the source of production. It is desirable that it be located a considerable distance ffommmain highways as passing vehicles help to disseminate the flies.

2. Drainage: Adequate drainage is essential. It is preferable to have hog feeding stations located on hilly ground and never on flat areas,

3. Adequate room: In feeding garbage it is essential in order to maintain sanitary conditions that the hogs be given a considerable acreage. I would would place this at a minimum of 225 sq. ft. per hog, or approximately 190 hogs to the acre. Of course as a general principle in fattening hogs it is considered necessary to reduce activity by close penning. It has been proven, however, that hogs make satisfactory gain when heavily fed if kept in large pastures.

4. Feeding troughs and platforms: Concrete feeding troughs and platforms are essential under the present inadequate labor conditions. A number of forms of troughs and platforms may prove satisfactory from a sanitary standpoint. In some cases feeding floors are used without any troughs, but this necessitates daily cleaning. Under outdoor conditions such as exist in the South, it is advisable to locate the feeding troughs on land with pronounced slope. A simple form of construction consists of a concrete platform about 15 feet wide, length in proportion to number of hogs. This should have a backward slope of about 10 inches. The trough can be formed by setting a plank on edge in the concrete about three feet from the upper side and parallel with it or by a concrete ridge several inches high to form the lower edge of the trough. The upper edge should be raised so as to prevent water from washing into the trough and the feed racks to receive the garbage constructed over the front edge of the trough in such a way as to receive all drip. The lower side should be provided with a concrete ridge projecting about five inches. This edge along the back will hold most of the unconsumed garbage, bones etc., and facilitates thorough cleaning which should be done not to exceed three-day entervals.

5. Shade: If location with plenty of trees can be chosen this is preferable to sheds for protention from the sun. Where sheds are needed for protection either from sun or rain they should be built on well drained land and never placed over the feeding troughs. They should be seven feet above the ground so as to permit of easy cleaning. Temporary shade can be constructed extending a few feet over the troughs if desired.

6. Contracts: Annual contracts with the Army are far more desirable than monthly contracts as it enables the contractor to put up proper feeding facilities which he would not do under short contracts.

7. Cleaning of yards: In addition to the cleaning of the unconsumed garbage from feeding platform the manure should be scraped up and disposed of, especially during rainy weather. During hot dry weather where ample pasturage is used manure is the source of very little fly trouble.

8. Disposal of bones: Bones which are not retained on the feeding platform and those which are mixed with uneaten garbage should be collected at four-day intervals and placed in fly-proof bone racks. These can be built of lumber and screened on the outside and provided with flyproof cover. It is desirable that the bones be removed entirely from the premises at frequent intervals.

9. Avoidance of transporting flies on vehicles. If garbage cans are properly cleaned there is less tendency for flies to follow them than if left dirty. Washing in a weak creosote solution tends to repel flies from them. The trucks should be washed off occasionally. There is less danger of flies following trucks back to army camps when they are provided with covers.

10. Quantity fed: Feeding so much garbage to hogs that it will not be cleaned up should be discouraged.

11. Final disposal of hog manure and unconsumed garbage: This material may be scattered thinly over cultivated ground and exposed to the sun or promptly plowed under. Where material is found to be heavily infested with maggots it is advisable to dump it in piles some distance from the feeding plant and treat it with borax solution. About one pound of borax should be used to each 8 bushels. If the mass is very wet the borax may be applied dry, but if the material will absorb liquid the borax should be dissolved in water at the rate of one pound to five gallons and sprinkled over it.

12. Dead hogs: Dead hogs should be promptly disposed of either by burning on the ground or by hauling to rendering plants.

13. Treatment of hog pens where flies are breeding: All manure should be scraped up thoroughly, holes cleaned out and the ground sprinkled with borax solution made as above. The holes should then be filled and packed; crude oil will assist in this. Lime has little value in destroying fly maggots but will tend to dry up moist areas and reduce odor. Ringing the hogs noses reduces the number of holes formed and is said to help keep them quiet in fattening.

14. Fly traps: Each hog feeding establishment should be provided with a number of well constructed fly traps, preferably of the conical type, and kept well baited. Black strap molasses and water at the rate of 1 part molasses to 3 parts water may be used as bait, or 1 part dark brown sugar to 1 part vinegar and 3 parts water may be used. The traps should be set in situations where flies tend to congregate and away from danger of being disturbed.

Hogs should not be tolerated in towns or cities. On farms the same general rules for elimination of fly troubles should be followed as applied to garbage feeding stations. For brood sows good dry clean housing is essential from both the fly control standpoint and that of successful breeding.

Prevention of fly breeding in chicken houses and yards: Comparatively little attention has been given to control of flies in poultry houses and yards. This source of fly breeding is one which should not be ignored as it is present even in far more premises than manure piles from horses and cattle. Several species of flies breed in chickens manure, but house flies and stable flies seem to predominate. The author has found many cases in the South in which these two species seem to be

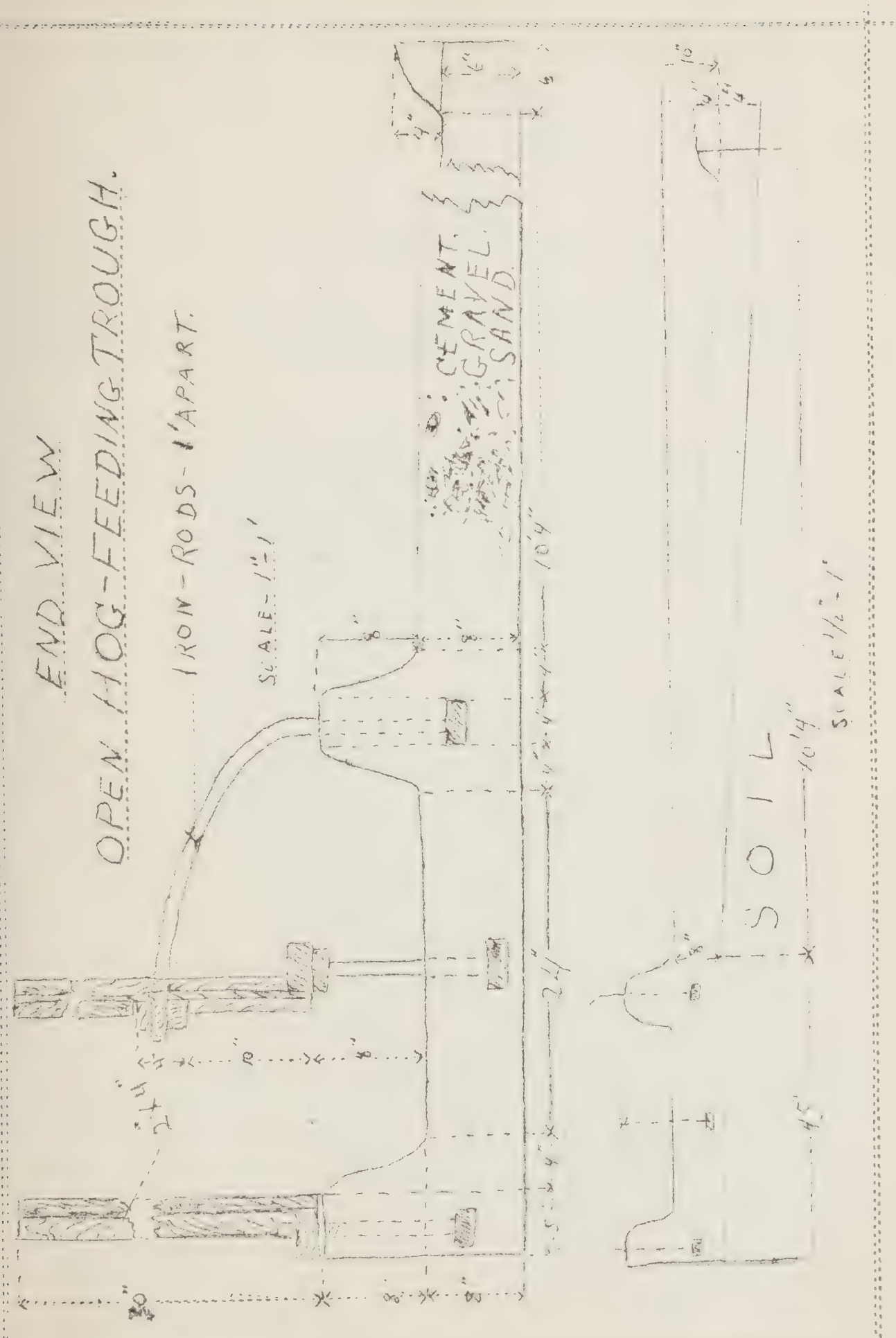
passing the winter in chicken manure. This appears to be a favorable place for the larvae to pass the winter as little heat is generated to hasten transformation and sufficient protection is afforded to prevent the destruction of the immature stages by cold.

With small flocks of poultry in the back yard the prevention of fly breeding is not difficult but is very likely to be neglected. We have found that flies will breed in rather small accumulations of chicken manure on dropping boards but are produced in greater numbers if the accumulations are on the soil itself. The weekly cleaning of all excrement from the dropping boards and floor is sufficient to prevent fly breeding. Usually it requires more than a few days droppings to produce a very favorable breeding situation. The cleaning of houses is of course facilitated by having the dropping boards readily removable or the roosts hinged so as to give free access to the boards. In the South dropping boards are not being advocated and very few places are provided with them. In such houses a concrete floor is very desirable to make cleaning easy, but seldom found. Sprinkling the dropping boards or floors with airslaked lime or dry sand helps to take up the moisture from the manure and reduce the attraction for flies.

In small places where gardens are available chicken manure can be used to advantage as fertilizer. Where it cannot be disposed of in this way promptly it should be placed in a box under cover from rain and treated with borax as previously recommended.

The care of yards and houses on large poultry farms should be handled in practically the same way as the small one just discussed. There is usually less trouble, however, from these large plants as they receive more constant attention than the small ones. Pigeonries are also a source of some fly breeding as the pigeon coops usually are placed in an inaccessible place and become very filthy. The houses should be made readily accessible and cleaned occasionally. Pigeons should be kept under control, and porcelain dishes provided for nests will facilitate cleaning.

The frequent and thorough cleaning up of the manure from all domestic animals and fowls tend to reduce the troubles among them from intestinal parasites. Spraying with standard disinfecting solutions has the effect of reducing the attractiveness for flies of excrement, soiled floors, etc., in addition to the germicidal action. Cleanliness and spraying also increase the efficiency of fly traps.


END VIEW
OPEN HOG-FEEDING TROUGH.
IRON-RODS-1' APART.
SCALE-1"=1'
CEMENT.
GRAVEL.
SAND.
10½"
24"
SOIL
10'4"
SCALE ½"-1'

CONTROL OF INSECTS LIKELY TO AFFECT THE HEALTH OF MAN AND ANIMALS IN CANTONMENT AREAS AS PRACTICED AT FORT WORTH, TEXAS.

By

E.W. Laake, O. G. Babcock, H.P. Wood, and F.C. Bishopp.

August 15 and 16 were spent in looking over the work of the Public Health Service under the direction of Capt. J.G. Townsend in the zone around the cantonment at Camp Bowie and the flying fields at Hicks and in the city of Ft. Worth itself.

Mosquito Control Work: Anti-mosquito work was first investigated. This work is in charge of sanitary engineers H. L. Crohurst and W.A. Hardenbergh. The main problems consisted in the drainage of flat areas fed by springs and the bath water from Camp Bowie which up to the present time had been discharged from the Camp through open ditches, in the handling of ponds formed in abandoned gravel pits, and work on the two branches of the Trinity River which meet near Ft. Worth. Drainage of the low areas was accomplished by simple surface ditching. A total of about 200,000 feet of drain ditches has been dug in the course of the work. This effectively disposed of the Camp Bowie water but left some water produced by springs which is kept constantly oiled. Camp Bowie is now being sewered throughout. It was found impractical to drain some of the gravel pits and the oiling method is followed up on these. Some cases the drainage was practically effected by digging wells to the hard pan and loosening this with charges of dynamite. The river was handled mainly by clearing the banks and ditching small pools, which were very few, into the main stream. This clearing was carried out up to two feet above low water mark and over twenty miles of bank were thus treated. A pond formerly used as a pleasure resort and known as Lake Como is located southwest of Camp Bowie. There is considerable seepage through the dam which impounds this water, making the lower side very favorable for the growth of vegetation and breeding of mosquitoes. This has been carefully ditched and the cow tracks and other small holes are oiled at weekly entervals. The lake itself has rather clean banks but in certain places would favor mosquito breeding. Objectionshas been raised to the oiling of this water but it has been given some oilings nevertheless. For oiling, a mixture of 70% fuel oil and 30% kerosene was used. This is applied by means of a knapsack sprayer to the surface of the water and edges of the pools. Application is made once each week to all possible breeding places and more frequently on certain ones which were most apt to give trouble. Minnows were observed to exist in the drainage ditches from springs and seeps and did not seem to be affected by the oiling applications. Of course this would not be true in comparatively still water. Up to the time of our visit comparatively little attention had been given to the breeding of mosquitoes in cisterns, barrels, etc., and inquiry among campers and other people in the edge of town not effectively protected by screens showed that the mosquitoes are annoying at night. These are probably mostly Culex. Some specimens taken in outbuildings during the day all proved to belong to this group. The anti-mosquito work has been favored during the present summer by the extreme drought which has reduced the water to a minimum and dried up practically all the smaller pools.

Fly Control Work: Dr. Thomas Parran took us over a considerable amount of the work relating to fly control which has been carried on under his direction. We were surprised to find livery stables in town which had been formerly centers of flies in countless numbers to be practically free from manure and flies comparatively scarce. Special attention had been given to the protection of foods. The ordinance on sanitation which has been passed by the city commissioners since the Public Health Service began work is rigidly enforced in regard to the screening of dispensaries of soft drinks, fruit stands, restaurants, etc.

Sanitary Privies: One of the most remarkable accomplishments of the Public Health Service in this district is the progress made in the installation of sanitary privies, not only in the city limits but in the outlying districts where in many cases no sewage is available and the people poor and have no knowledge of the first principles of sanitation. Dr. Parran states that over 2,600 box privies have been installed and several hundred of the more permanent concrete compartmat type. Up to the time of our visit all but thirty families on the north side had arranged to either connect with the sewer or put in box privies.

The box privies are either of the one - or two - can type. One of the remarkable features is that the cost of the privies is borne by the people, and apparently quite willingly. The construction and installation are contracted for by the city and the people pay the city treasury $8,50 or $11.00, according to the type used- one or two hole - when the privy is installed. Usually the box is put in the house already in use, the seat being torn out and used to finish out the floor. One of the essential features of the use of this privy is of course the maintenance of an adequate scavenger service and the prompt and thorough cleaning of the receptacles. As soon as this service falls below the standard the whole advantage of the sanitary privy is lost.

We were impressed by the freedom from odor around these privies and the comparative absence of flies. Of course the hot dry weather probably favored both these conditions, but the ventilation is undoubtedly partially responsible for the lack of odor. Dr. Grady Shytles has been supervising the installation of the sanitary privies in the district around Hicks field. The village of Saginaw is a model in this respect, every family having a privy, most of them being of the concrete vault type. This same type has also been used extensively around Lake Worth which is a summer camping ground for many people and being on the lake which furnishes the water supply, not only to the city but to Camp Bowie, requiring that extraordinary precautions be taken looking to the proper disposal of human excreta. This concrete pit type was originally designed by Dr. Lumsden of the Public Health Service, but certain minor improvements have been made by Dr, Shytles and others of the local force. These privies consist essentially of a concrete receptacle about 3 1/2 feet deep and with a solid partition from front to back. Two seats are provided on concrete hoppers. Only one of these is used at a time. When the concrete cell becomes nearly full that side is closed and the other used. By the time the other is filled the first side has become inert as regards odor and bacterial activity and is then cleaned out and again used while the other side is closed for a similar period. Occasionally a couple shovelfuls of dirt are thrown into the pit to absorb the liquids. These privies, like the wooden boxes, are provided with ventilating stacks and the odor is reduced to a minimum. A series of these units are used in community camping grounds and factories. The cost of construction under the Ft. Worth conditions was approximately $22.00 to $25.00, not including the house which is really an unessential part. Two square openings

are left in the concrete behind the hoppers. These project out behind the house, are closely boarded and covered with roofing. Through these the excrement is removed. This arrangement, together with tightly fitting seats and screened ventilators, makes the privy fly-proof and only improved upon by the installation of an adewuate sewer system. Of course where sewer connection could be had they were made. Over one hundred houses were connected per week during a period of several months.

Establishments where Hogs are Fed Garbage; Three of these establishments are now in operation in the Fort Worth district but only one of them has been causing complaint. This establishment was first operated in the village of Saginaw and received the garbage from hicks field. It became a nuisance and through the help of the Public Health officials was removed to another place. There was still much to be done to render this place less of a menace to public health. About 500 hogs are being fed garbage at this point. The hogs are kept rather closely penned in an area of probably less than an acre. Inadequate shade is provided in the form of low sheds and these extend over the feeding troughs which are never cleaned except to shovel the garbage out of them and under the sheds. The overflow of the feeding troughs and the unconsumed material make a filthy wet wallow in which the hogs lie during the heat of the day. Although this site has been occupied less than a month hog manure has accumulated in parts of the pen to a considerable depth and flies are breeding freely. Flies are also produced in refuse about the troughs and adult flies, although numerous now, would be produced by the millions upon the cessation of the extreme hot dry weather. The main objectionable features to this feeding pen are the failure to provide good feeding troughs and platforms and to clean out the unconsumed material and effectively dispose of it, the low sheds beneath which the soil is rough and rocky, and the inadequate room for the number of hogs fed.

Two other places are maintained near Benbrook west of town. These are operated by Mr. Johnson who has contracted for the garbage from Camp Bowie, the flying field near Benbrook, and another south of Ft. Worth. The largest of these feeding places was visited. When Camp Bowie was well filled about 1,700 hogs were fed at this place. At present about 900 hogs are kept. These are ranged in two fields totaling about 80 acres. The area is very hilly and consequently well drained and ample shade is provided by trees, etc. The feeding troughs are of concrete and about of the type which we think is best for the purpose. Behind the troughs there is a sloping concrete platform about eight feet wide. If this platform had a projecting edge to prevent the unconsumed garbage from being pushed off on the hillside below it would help maintain the place in good condition. The large range permits the hogs to defecate in areas well removed from the feeding quarters and greatly reduces the chances of fly breeding. The pens near the feeding troughs are scraped up occasionally and the bones picked up and sold for fertilizer. It will be necessary to do this more frequently when showery weather begins. One of the main difficulties experienced in maintaining the best sanitary conditions is the shortage of labor. The cleaning of the garbage cans seems to be handled satisfactorily. They are washed in salsoda and caustic solution inside and out and seem to be free from dirt and grease. Dead hogs are promptly removed to rendering plants in town or burned.

On the whole it appears to us the Public Health service has accomplished remarkable results in the short time they have been operating in the Ft. Worth district, both in insect control and many other lines calculated to guard the public health While there are still some things which can be improved the officials have the work well in hand and are following the anti-insect work vigorously.

BUREAU OF ENTOMOLOGY
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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY

OF DISEASE, HYGIENE AND SANITATION,

Lecture 15,

Sept. 9, 1918. COMMON FLIES AND HOW TO TELL THEM APART.

C. T. Greene.

Flies are not only a nuisance to man but are really dangerous because they are capable of carrying many disease germs from place to place. They will walk over dead and decaying matter and probably the first place where they alight, after leaving this decaying material, will be some dinner table. If they should find a dinner table the first place to stop would be on the food and in this way many germs can be scattered by a single fly.

The common "house fly" is a fly known by everybody and is a very common carrier of germs, and is often spoken of as the "typhoid fly."

The body and legs of the fly are covered with many hairs and when the fly crawls over infected material many germs stick to these hairs and the next object upon which this fly alights naturally receives a great many of these germs. Food is an exceptionably fine receptacle for germs. Even more dangerous than the transferrence of germs on the legs and body of the fly is the fact that bacteria are found in greater numbers and livellonger in the alimentary canal. Very often flies may be seen with a tiny drop of clear liquid at their mouth. These little droplets (sometimes called "vomit spots") are regurgitated matter and each droplet contains a great many germs. A great many germs are also voided in the excreta of the fly.

I have only included a few of the very common flies in this paper, the flies that are likely to appear near any house or in any camp. All of them may be attracted by the odors of fresh and cooking foods. In the following pages I have made two tables, one to separate the different species of the adult flies and the other to separate the different larvae or maggots of the flies. All the terms for the different parts of the flies and maggots have been made as plain as possible so that the tables can be used by a non-entomologist. In the first table for the adult flies, I have given the style of the mouth-parts, that is whether they are adapted for biting or simply suctorial, then the common name is given and then the scientific name. In the second table the larva or maggor can be separated into the different species. Then on another page, under the name of each species, the larva or maggor is described in further detail and here mention is made as to where the species will breed.

All the sarcophagid or "flesh flies" can be readily separated from all the other flies because their bodies are entirely gray. The head is rather a bright red, the top of the back has three parallel dark stripes and the top of the abdomen has lighter reflecting areas giving it somewhat of a checkered appearance.

Table to Separate the Adult Flies.

1. Dark gray, medium sized fly; top of thorax with four, parallel, black stripes; sides of abdomen with a large yellow area (variable in size and never def-

initely outlined; mouth-parts of the suctorial type, (see fig. 2) (never for biting); variable in size but average about 1/4 inch in length. The common house fly (figs. 1 & 4) also called, Typhoid fly/
- -Musca domestica, L.

2. Brownish-gray fly, slightly larger and broader than the house fly. Top of thorax with two, long, parallel, black stripes and on each side of these is a large black dot, below which is a black stripe about half as long as the two long stripes. Abdomen with two or three cone-shaped dark brown spots in the center and two ro three round spots on each side (fig. 6). Mouth-parts piercing or biting type (fig. 3). Stable fly, also called biting house fly.
- Stomoxys calcitrans. L.

2a. Very dark gray fly, smaller and more slender than the house fly. Abdomen pointed and more conical in shape. Yellow spots on the sides definitely outlined (fig. 5). Mouth-parts are of the suctorial type (fig. 2). The small house fly.
- -Fannia canicularis L.

3. Gray fly, a little larger than the house fly. (about the size of stomoxys calsitrans.) Top of thorax has two, short, black stripes. Abdomen is gray and in certain lights there are paler gray areas which look like sptos but there are neger any definitely outlined spots. Mouth-parts suctorial type (fig. 2). Another stable fly.
- Muscina stabulans, L.

4. Large blue fly, (average length three eighths to seven sixteenths of an inch). This fly is rather broad and robust and in certain lights the abdomen shows paler, reflecting areas but not definite spots. Mouth-parts suctorial type (fig. 2). The common blow fly. Meig.
- -Calliphora erythrocephala./

4a. A larger fly about the same size as the above but more shiny and a deep greenish blue. Abdomen slightly more pointed and of an even coloration (no reflecting spots). Mouth-parts suctorial type (fig. 2) Another blow fly,
- -Calliphora vomitoria L.

5. Much smaller fly, shiny, metallic green with a decided bluish tinge. Mouth-parts of the suctorial type (fig. 2) Small green-bottle fly
- Lucilia caesar, L.

6. Another small fly, shiny green with a decided brassy tinge. Mouth-parts suctorial(fig 2). A green-bottle fly.
- Lucilia sericata, Meig.

7. A dark green fly, little larger than the above species. It is shiny with bluish tinge. Top of thorax with three dark longitudinal stripes. Thorax often has a bronze tinge. (average length five sixteenths to three eighths of an inch.) Mouth-parts of the suctorial type (fig. 2). The"screw-worm fly- - - - - - - - - - - - - - - - -Cochliomyia macellaria (Chrysomyia), Fab.

8. Deep, shiny blue fly often with a blackish tinge, (about five sixteenths

of an inch in length) Mouth-parts of the suctorial type (fig. 2). The black blow fly.- - - - - - - - - - - - - Phormia regina.

9. Ashen gray to deep gray flies. Top of thorax with three blackish, longitudinal stripes. The abdomen has lighter gray reflecting spots (in certain lights). The different species varyin size from a small fly up to a half inch in length. Mputh-parts are suctorial type (fig. 2) Flesh flies. F -Sarcophagidae.

THE LARVAE OR MAGGOTS.

There is a considerable number of flies whose larvae or maggots either regularly of occasionally live in substances used by man as food. The great majority pass through the intestinal tract without our knowledge, for most of them cause little or no trouble. Many dipterous larvae occur in decaying fruits and vegetables and on fresh and cooked meats. The blow fly for example, will deposit on meats in a pantry; while other maggots occur in cheese, etc. Pies and puddings in restaurants are often accessible and very suitable places for flies to deposit their eggs and no doubt a great many maggots are swallowed in this way. The occurrence of Dipterous larvae in man is known as "myiasis". Various names or divisions areggiven, as "myiasis externa" or "myiasis dermatosa" for larvae in the skin or wounds; "myiasis intestinalis" for those in the alimentary canal. "Myeasis narium" for larvae in the nose. The presence of larvae in the nose is rather accidental in this country and usually due to the "screw worm." In tropical countries this type of myiasis is quite common.

The larvae of the ox warble or bot-fly (Hypoderma lineata, Villers) sometimes occurs in man. The eggs of this species are deposited upon the hairs of cattle and licked off by the animal, develop in the stomach, and the larvae bore upward to the back, there to cause the "warble". If some of these eggs drop into the milk pail there is a chance that they will be swallowed by a person. So there are various cases recorded, mostly of children, where, in the winter time, a larva is observed under the skin, usually in the neck or shoulders, and upon removal proves to be the larvae of the bot-fly in the second stage. This infestation is sometimes called "creeping worms," and many cases have been recorded by army surgeons on the Mexican border.

Descriptions of Larvae or Maggots.

All the larvae mentioned here are broadest near the tip or tail of the body, and taper forward to the head.

The larvae is divided into eleven parts, called segments, and the first segment is the head. The head appears to be bilobed, or divided into two parts when viewed from above, and each lobe bears a minute cylindrical, tubercle or papilla (fig 7-A). Below is the mouth opening; at one side and above it is the pair of mandibles or great hooks (fig. 7-B). The second segment bears on each side, in the full grown larvae, a short fan-shaped process, called the anterior spiracle (fig 7-C). For further details wee fig. 7.

TABLE TO SEPARATE THE LARVAE (MAGGOTS).

1. A larva with the body flattened: Down the middle of the back are two rows of spines or processes, there are also two rows along the under side and a single row of spines along each side. These spines or processes are pointed and covered with many bristles. There are also two stigmal plates on top of the last segment. Fig 11 - - - - - - - - - - Fannia canicularis.

With one great mouth-hook; slits in stigmal plate winding.

2. Body broadly rounded at rear end, without spines. Stigmal plate with three winding slits (figs. 8 to 10)----------Musca domestica.

3. Body same as above species, stigmal plate with three S shaped slits (fig. 23)- -Stomoxys calcitrans.

Two great mouth-hooks, slits in stigmal plate not winding.

4. Body slightly rounded at rear end, faintly spined and with three short, pointed slits in stigmal plate (fig. 22)
- -Muscina stabulans.

5. Stigmal plates wide apart, each plate with three, straight slits nearly transverse to the body and a distinct button (fig. 26).
- Calliphoria erythrocephala.
(Calliphoria vomitoria)

6. Stigmal plates about half their diameter apart, each with three straight slits directed somewhat downward.
- -Lucilia sericata.

7. Stigmal plates less than their own diameter apart, each with three straight slits pointed downward; no button (fig. 18).
- Cochliomyia macellaria (Chrysomyia).

8. Stigmal plates at bottom of a deep pit; each plate has three slits pointing downward, plates less than their diameter apart; no button.
- Sarcophagidae.

Fannia canicularis L.

This larva is brownish yellow in color. The body is quite flattened, narrow and pointed in front. The peculiar spines or projections on the body will separate it from the other species. The larva averages nearly three-eighths of an inch in lenght (fig. 11.)

Since larvae of this genus feed on fruit and vegetables that are just beginning to decay one can readily see that they are often swallowed by people There are many records of the passage of larvae or maggots of this genus.

At least some species of this genus breed in human feces, therefore they may be possible conveyers of disease.

Musca domestica.

The larva of the house fly (fig. 8) is slender and tapering in front and large and somewhat rounded behind. From above, the head is divided into two parts with a tiny papilla on each side (fig. 9) and there is but one great hook. The anterior spiracles (fig. 8a) show six or seven lobes; on the under side of the sixth and following segments there is a transverse, swollen area, wider in the middle and somewhat pointed toward each end. These areas are provided with minute teeth. The area is slightly prominent and shows two approximate processes. The stigmal field is barely if at all concave and not outlined by tubercles; the posterior spiracles (fig. 10) are prominent, less than their own diameter apart and each with three, winding slits and a button at the base. In some cases two of the winding slits are apparently connected. The second stage larvae has two straight slits in each stigmal plate, while in the first larval stage there are two smaller slits on a tubercle each side of the middle and in this stage there are no anterior spiracles. (8a)

The larva of the house fly is rarely swallowed, but there are records to that effect. It sometimes breeds in decaying fruits and vegetables. The principal breeding place is in horse-manure. It also breeds in human excrement and because of this habit it is very dangerous to human beings.

Stomoxys calcitrans, L.

The larva of this species is very similar to that of the house fly, with a single great hook; the anterior spiracles have five lobes, (fig. 24); the sixth and following segments have each an area on the under side provided with tubercles, this area is wider in the middle; anal area has two submedian tubercles and three each side of these; above them is a row of minute granules, ending each side in a larger granulate tubercle; there are no tubercles outlining the stigma field; the stigmal plates are sub-triangular, about one and one-half times their diameter apart, black, and each with three pale areas containing an S-shaped slit (fig. 23). These slits are never near each other like in the house fly, and there is no apparent button.

This larva commonly breeds in manure of various kinds, but also in decaying matter, and is not often passed by people, but there is one record. Horse manure, cow manure, and warm, decaying vegetabion, like old straw and grass heaps are common breeding places.

Muscina stabulans, Fallen.

Head of larva (fig. 9) divided into two parts from above, no distinct papilla; two great hooks close together; anterior spiracles with about six lobes (fig.20). The surface of the segments is mostly smooth. Beginning with the

fifth segment, on the under side, there is a basal, transverse, swollen area, furnished on the crest with rows of teeth; each of these areas is divided on the median line. On the next to the last segment there is a similar area at the tip,, but noe divided. The segments below also show a transverse line before the middle. The last segment has the anal basal area with spines, but not very prominent, and bears a median and three lateral tubercles with spines. The tubercles are nearly in a transverse row; The rounded tip of the body (fig. 21) shows, across the middle, faint traces of four, low cones. The stigmal plates (fig. 22) are scarcely elevated, black, less than their own diameter apart, and each with three very short slits pointing towards those of the opposite plate.

This larva is common in decaying vegetable matter; and has been reared from rotten apples, pears, squash, mushrooms and dead insect larvae. In one case a considerable number were passed by a child suffering with summer complaint. Laboulbene records larvae of this species vomited by a person suffering from bronchitis.

Calliphora erythrocephala, Meigen.

The head of this larva is distinctly divided into two parts from above (fig. 25), side view of head) each part or lobe has a tiny papilla. There are two well separated mouth hooks. The anterior spiracles have from nine to twelve lobes. Beginning with the third, each segment shows an apical swollen ring or girdle, whose surface is scabrous (roughened like a file); these rings are broader below than above,and are here notched on the posterior middle. Each ventral segment, beginning with the fifth, is divided by a transverse groove near the middle. The anal area shows a smooth median process, divided in the middle. The anal area shows a smooth median process, divided in the middle, and at each outer corner is a cone. The stigmal field is rather concave, the upper lip with three small tubercles on each side, the lower lip with two larger tubercles on each side, and a median pair smaller and lower down. The stigmal plates are about once and a fourth their diameter apart, each with three simple straight directed slightly downward but mostly toward those of the opposite plate; the button is distinct. (fig. 26)

The blow - fly deposits eggs on dead animals, and also on fresh and cooked meats. As such are often accessible to them in pantries, it is readily seen that many larvae are, are swallowed by people each year; there are, however, comparatively few records, probably because the food causes no trouble.

Calliphora vomitoria, Linne.

This larva seems to be identical with that of Calliphora erythrocephala. There seems to be no visible characters to separate it from this latter species (figs. 25 and 26). The habits are about the same.

Lucilia sericata, Meigen.

Body rather stout, not slender in front. The head is distinctly divided into two parts or lobes, with distinct papilla (fig. 12-13), The two great mouth-

hooks are well separated. The anterior spiracles are provided with about eight lobes. The surface of the body is mostly smooth; the sides of segments 3,4, and 5 are bilobed; beginning with segment 6 there is a basal ring girdle, roughened these girdles on segments 6 to 9 are widened on the middle of the under side of the larva; the sides are also swollen, but not plainly bilobed, except those near the tip. The undersides of the segments are transversely divided by a line or furrow in the middle. The last segment is short,the stigmal field occupying most of the tip. The stigmal field has a slightly depressed, upper lip with three sharp tubercles on each side, the intermediate one hardly smaller than the others; and a lower lip with two large, sharp, tubercles on each side, and a median, pair more remote from the margin. (fig. 14) The anal area is rather sunken, with a small rounded tubercle at each outer corner. The stigmal plates are about one-half their diameter apart, each with three straight slits, directed somewhat towards each other, but also downward.

This larva is mentioned on account of the adult which is very likely to be met with. This larva is mostly injurious to sheep. Meinert has reared another Lucilia (L. nobilis, of Europe) from larvae taken from the ears of a sailor.

Cochliomyia macellaria, Fab. (Chrysomyia).

The head from above is distinctly bilobed (fig. 15). There are two distinct hooks. The anterior spiracles are very short, and contain only 7 lobes (fig. 17). The posterior upper part of segment 1 is swollen and with many spines (fig 15). Each of the following segments (except 2) has a basal, swollen ring, armed with teeth pointing backward, the teeth of the front rows are always larger. Beginning with segment 6 the under part of each ring is much broadened and divided transversely by a narrow smooth space. On segments 5 to 10 there is on each side behind, a fusiform swollen area pressing against the swollen ring of the next segment; this area also has spines. The tip of the body shows on the dorsal part a great cavity in the bottom of which are the stigmal plates, each with three straight slits, those of one sub-parallel to those of the other; there is no button (fig. 18). Behind this cavity is a high, transverse, spiny crest; and the ventral part of the tip shows an area covered with spines bearing two rather widely separated, prominent, smooth tubercles. The upper edge of the tip shows four small conical tubercles. The larva of this insect is called the "screw-worm", and occurs in sores and wounds of domestic animals and also in man. There are various records of its presence in the ears and nose, or nasal cavities, of people; from swellings near the nose; from a boil under the arm; from under the skin of a child; and in the navel of a child. It is hardly a possible factor in intestinal myiasis, and most of such recorded cases probably belonged to some species of Sarcophaga whose larvae are very similar in appearance to those of the screw-worm.

Sarcophagidae.

The Sarcophagidae have two great hooks, and the posterior stigmal plates have three slits as in Calliphora erythrocephala and Lucilia sericata. However, these slits are not directed toward those of the opposite plate but are subparallel to them. The stigmal field is strongly depressed to form a deep pit, and the stigmal plates are at the bottom of this pit. The segments of the body bear

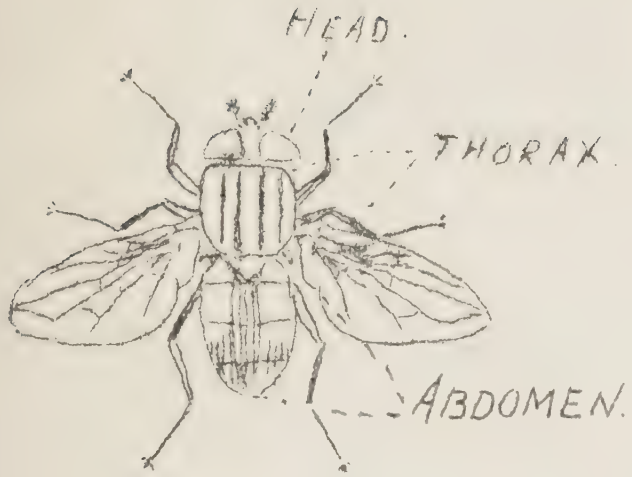
complate rings of spinose areas, and often supplementary pads on the sides.

Sarcophaga larvae prefer animal matter, and have been found in cheese, oleomargarine, pickled herring, dead insects, and human feces. A species was also reared from decaying vegetables.

List of Illustrations

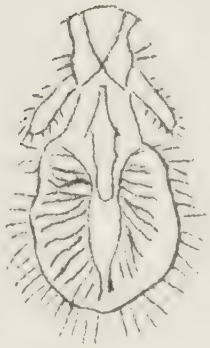
1. House fly. Showing parts of the body.
2. Mouth-parts. Suctorial type.
3. " " Biting type.
4. House fly. Abdomen showing markings.
5. Little House fly. Abdomen showing markings.
6. Stomoxys calcitrans. Abdomen showing markings.
7. A larva or maggot giving the names for the different parts.
8. House fly larva.
8a. " " Anterior or front
9. " " head from above.
10. " " posterior plate
11. Little house fly larva.
12. Lucilia sericata, head from above.
13. " " head side view.
14. Lucilia sericata. End of body-side view.
15. Screw-Worm. Head side view.
16. " " tail end side view.
17. " " anterior spiracles.
18 " " posterior "
19. Muscina stabulans. Head side view.
20. " " Anterior spiracle
21. " " Tail end, side view.
22. " " Rear spiracles.
23. Stomoxys calcitrans. Rear spiracle.
24. " "
25. Calliphora erythrocephala, head, side view.
26. Same Rear spiracles.

CHARACTERS OF THE ADULT FLIES.

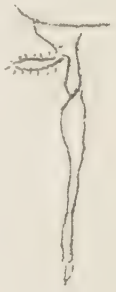


MUSCA DOMESTICA L.
1

MOUTH PARTS



SUCTORIAL TYPE
2



BITING TYPE
3

ABDOMINAL MARKINGS



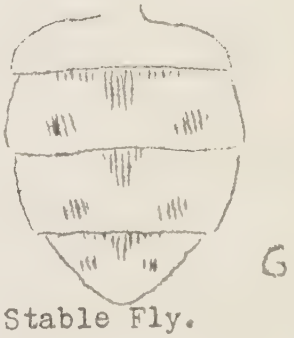
House Fly

Musca domestica, L.



Little House Fly

Fannia canicularis. L.



Stable Fly.

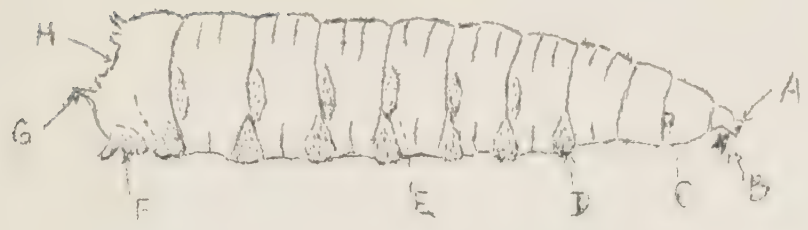
Stomoxys calcitrans, L.

In figures 4, 5, and 6 the relative size of the abdomen is shown. The light area in figs. 4 and 5 represent the yellow markings and they are variable in size. In fig. 4 the yellow markings or spots may be much smaller or larger according to the specimen examined.

In fig. 6, the markings on the last or pointed segment may be present or absent.

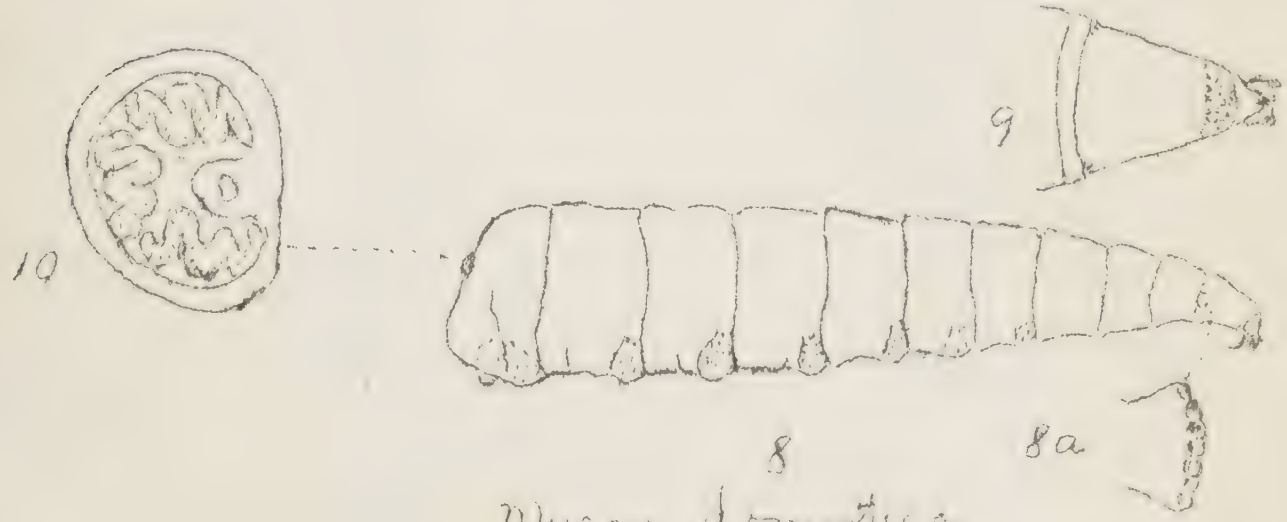
CHARACTERS OF THE LARVAE. (MAGGOTS).

A typical Muscoid larva.

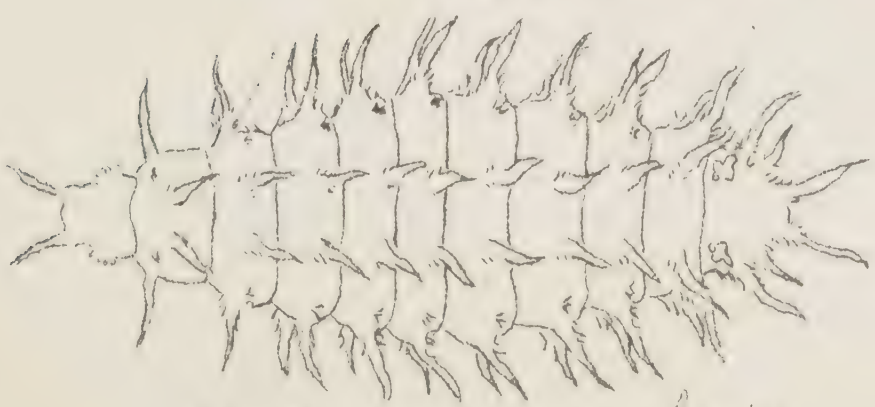


7

A----Papilla of the head. (A thimble shaped projection)
B----Great hooks (also called the mouth hooks)
C----Anterior spiracles or breathing pores.
D----Ventral fusiform area. (widest at the middle, tapering to a point at each end.)
E----Lateral fusiform area.
F----Anal tubercle. (Athimble shaped projection)
G----Apical spines. (Pointed projections on the edge of the stigmal field)
H----Stigmal field. (A flat or sunken area containing the posterior plates)
The posterior plates are also called the posterior spiracles. These plates contain the slits which are the spiracles or breathing pores. There are always two of these plates.



Musca domestica



11. Tania Canicularis.

LARVAL CHARACTERS.



12.

Head - above



13.

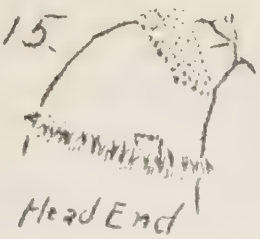
Head - side



14.

End of body.

Lucilia sericata Meig



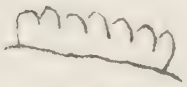
15.

Head End



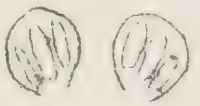
16.

Tail End



17.

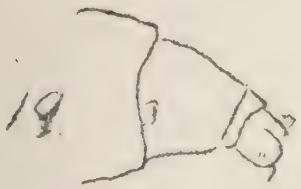
Anterior Spiracle



18.

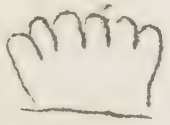
Posterior Spiracles

Cochliomyia macellaria Fab.



19.

Head



20.

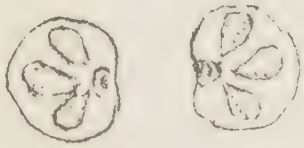
Anterior spiracles

Muscina stabulans F.



21.

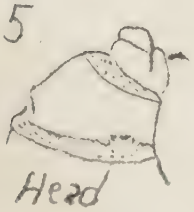
Rear End



22.

Rear Spiracles

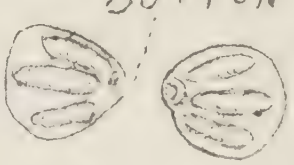
Muscina stabulans F.



25

Head

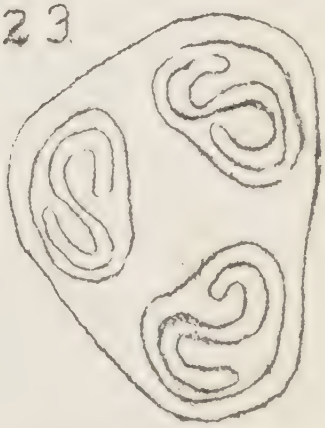
BUTTON



26

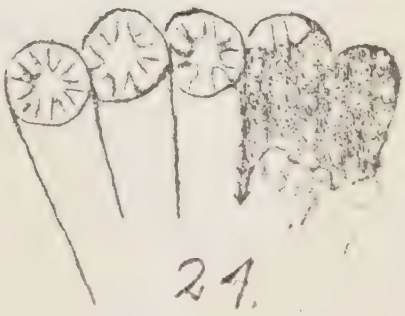
Posterior Spiracles

Calliphora erythrocephala Meig
Calliphora vomitoria L



23.

Stomoxys calcitrans L.



21.

Stomoxys calcitrans L.

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BUREAU OF ENTOMOLOGY
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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY

OF DISEASE, HYGIENE AND SANITATION.

Lecture 16. WHAT WE SHOULD KNOW ABOUT MOSQUITO BIOLOGY.

September 16, 1918.

W. Dwight Pierce and C.T. Greene.

Entomologists are generally better informed about the life history of mosquitoes than of most of the insects which carry disease. It is therefore more essential at this time to sketch over some of the points to which we as sanitary entomologists must pay attention.

Any one studying mosquitoes must before completing his study digest the wonderful mass of material in Howard, Dyar and Knab's Monograph, especially volume 1.

All mosquitoes pass their early stages in water. They cannot develop in any other medium.

The adult mosquito is known to every one, but its eggs deposited on the water are the least known. The larvae, commonly known as wiggle tails and the peculiar shaped pupae are fairly well known.

The different species of mosquitoes are more or less selective as to the type of water in which they breed, and careful study of mosquito habitats is essential to all who have to do with mosquito sanitation. Therefore we must at least to day consider the habits of all our American disease carrying mosquitoes. Many of the others may be capable of carrying disease, but no proof has been brought forward against them.

In lecture 13 it was shown that the following mosquitoes of the United States are disease carriers.

Dengue fever is carried by Culex quinquefasciatus (fatigans), and Aedes argenteus (Stegomyia calopus or fasciatus).

Yellow fever is carried by Aedes argenteus

Subtertian or aestivo-autumnal malaria is carried by Anopheles crucians, pseudopunctipennis, punctipennis, and quadrimaculatus.

Quartan malaria is carried by Anopheles quadrimaculatus.

Tertian malaria is carried by Anopheles crucians, punctipennis and Quadrimaculatus.

Filariasis is carried by Culex quinquefasciatus, and Aedes argenteus.

These six species of mosquitoes are then the ones most to be feared in our own country. One travelling in other countries must guard against entirely dif-

ferent species.

OVIPOSITION AND THE EGG STAGE.

Mosquitoes lay their eggs in various ways. The mode of deposition best known is that ot laying all the eggs at once in a so-called raft. The eggs are cylindrical, rounded at the ends and tapering to the upper end. They are placed in an upright position and fastened together by a viscous secretion. They are deposited upon the water or near to it. Such is the type of oviposition of Culex and several other genera.

Some mosquitoes, as Culex jenningsi, surround the eggs with a gelatinous mass which furnishes the first food to the newly hatched larvae.

The various species of Anopheles deposit the eggs separately in small numbers on the surface of the water. The eggs lie upon their sides are kept afloat by a peculiar hydrostatic organ, a partial envelope which is more or less expanded, particularly along the median portion of the egg. This organ is variously shaped in the different species of Anopheles and is called a float.

Of the mosquitoes which lay single eggs some fasten them by a gelatinous substance at the margin of the water, others lay them on the ground where they remain until rains provide sufficient moisture for hatching. Some of these eggs are enabled to float because of spinose tubercles which hold the air between them. The species of Aedes lay their eggs singly and not all at once. Thus it happens that eggs laid in the summer in northern latitudes lay over to the next spring.

Aedes argenteus Poiret, (see fig.1) the yellow fever mosquito, lays eggs measuring 0.53 mm. long and 0.15 mm. in diameter. They are black, fusiform, very slightly flattened on one side, slightly more tapered toward the micropylar end; sculptured with rough, somewhat irregular rhomboidal callosities forming spiral rows. Under natural conditions the eggs are laid singly in small irregular groups some distance above the margin of the water, they are laid in from one to seven days after the female has fed upon blood, and usually are laid at intervals after successive blood meals.

Culex quinquefasciatus Say, the dengue fever mosquito lays its eggs in boat-shaped masses floating on the surface of the water. It may lay from 180 to 350 in a mass in 7 to 11 rows. The eggs hatch after one to three days. An egg mass of Culex pipiens, our common house mosquito is shown in fig 2.

Anopheles crucians Wiedemann has an elongate fusiform eggs (fig. 5), slightly more tapered toward one end, both ends rounded. The dorsal surface is granular, the ventral surface coarsely hexagonally reticulate. The floats occupy about half the sides in top view, and are separated at the middle by nearly one third the diameter of the egg. These eggs are laid singly, a small number at a time, upon the surface of the water.

Anopheles punctipennis Say (fig. 3) has an elongate fusiform egg, reticulate ventrally, finely granular dorsally. The floats are large, extending nearly to the apices, closely approximated medianly on the dorsal surface, arcuately produced at the sides to the apical fourths, widely separated on the ventral surface and showing only on middle third of sides. The eggs are laid singly or in small groups upon the surface of the water.

THE LARVAE AND THEIR HABITS.

All mosquitoelarvae are aquatic. By far the most of the larvae occur in small deposits of water, although certain species occur in large bodies of water. Those species which lay there eggs on the ground in dry regions, hatch as soon as rains occur and the larvae go through a very rapid development. Such species show a rather marked periodicity in broods. Species which have abundance of water breed continuously during the warmer seasons. One is apt to find mosquito larvae whenever water occurs.

The food of the larvae varies, but usually consists of the minute forms of plant and animal life in the water, although certain species are predaceous, and some are scavengers upon the dead animal and insect life in their habitat.

The larvae of mosquitoes are very peculiarly constructed. The mouth is furnished with tufts of filaments which are constantly in vibration. The head is larger, the antennae long, the thorax somewhat swollen, and the abdomen slender. The sides of the body are furnished with stiff bristles. From the next to the last segment there protrudes a long tube nearly as thick as the body itself, and it is this tube that touches the surface of the water when the larvae rises to breathe. When in this position the larva hangs downward in various attitudes characteristic of the species. The object of this tube is to get air. At the extremity is a breathing hole, or spiracle, and into it run two main tracheae which extend through the body of the insect with many branches which carry air to all parts of its tissues. The true anal end of the body is furnished with four more or less developed tracheal gills.

When suspended from the surface the wriggler's mouth parts ann constantly in vibration, bringing into its mouth any minute particles which float in suspension in the water.

It is when the larva extends its breathing tube from the surface of the water that it offers the greatest opportunity for control. All efforts to maintain an oil film on the surface of the water are aimed at clogging up this tube when it comes to the surface, and thus cutting off the air supply.

Occasionally the larvae descends to the bottom, jerking its body violently from side to side. The anal tracheal gills undoubtedly assist in this motion. The larvae are active and move backward through the water by these jerky movements. They can move slowly forward by the action of the mouth bruches. Some species are specially equipped for obtaining air from the water or from plants and do not come to the sufface. This is fortunately mot the case with those we are most interested in.

Aedes argenteus larva (Fig. 9.) has the head rounded, widest behind the eyes. The thorax is rounded, wider than long, with moderate, rather sparse hairs. The abdomen is rather long, the tracheal tubes are broad, band-shaped. The air-tube is stout, short, strongly tapered on outer half, over twice as long as wide, with the pecten running nearly halfway, followed by a single tuft of a few hairs. Each single pecten-tooth is a rather long spine with two large and some small teeth within and small ones without. The lateral comb of the eighth segment is composed of ten scales in a single row. The anal segment is short, wider than long, almost ringed by the plate, which nearly touches ventrally, but is not

united. The ventral brush is moderate, directed posteriorly. The anal gills are long, wide, tracheate, with rounded tips.

The larvae live in accumulations of water in artificial receptacles. Originally it was a tree hole inhabiting species, but is now wholly domesticated and is found in houses and in the vicinity of hyman habitations. The larvae thrive very well in water containing food refuse and in muddy water.

Culex quinquefasciatus larva (fig. 10). has the head rounded, widest through the eyes. The thorax is rounded, wider than long. The abdomen is moderatelywith the anterior segments shorter. The tracheae are rather broad. The air tubeis rather stout, tapered on outer half, four times as long as wide, with the pecten running about one-third, each pecten-tooth is broad with three to six branches. The lateral comb of the eighth segment is composed of many spines in a triangular patch. The anal segment is a little longer than wide, ringed by the plate. The ventral brush is well developed, confined to the barred area. The anal gills are rather short and broad, longer than the segment, tapered toward tips.

The larvae are found most frequently in artificial receptacles, but also in ground pools in the vicinity of habitations when the water is sufficiently polluted. The species thrives best in water charged with animal matter and shows a preference for filthy water. Breeding foes on continuously while conditions are favorable. Under the most favorable conditions the larval period may be five or six days.

Anopheles crucians larva has the head rounded, elongate, bulging at the sides, with the frontal portion before the antennae conically produced, The thorax is rounded quadrate, about as long as wide. The abdomen is stout, with the anterior segments shorter. The air tube is sessile, subquadrate, roundedly angled posteriorly · The lateral plates of the eighth segment iar posteriorly armed with a series of spines, about eight long stout ones, separated from each other by from one to four short spines. The anal segment is about as long as wide, with a small dorsal plate. The ventral brush is well developed, of long branched tufts. The anal gills are moderate, about as the segment, slightly constricted centrally, blunt pointed.

The larvae live in ground-pools, usually in tidal marshes. Breeding also occurs inland. Below New Orleans it is an abundant pest in the salt and brackish water marshes, where it occurs in undiminished numbers even in the winter.

Anopheles pseudopunctipennis larva differs but little from the preceding but may be separated in the table which follows.

This species is somewhat discriminating in choice of breeding place. It prefers as a rule water of great purity and rapidity of current. The larval food is by preference the soft green algae. It has been found, however, in irrigating ditches, in claar quiet pools formed by the overflow of a watering trough, in ditches, pools and puddles, in tanks, well-holes and spring-holes full of algae.

Anopheles punctipennis larvae (fig. 11) are found in all sprts of water in ground-pools and streams and occasionally in artificial receptacles. The larvae are found all the season breeding being continuous until winter. The larvae occur most commonly in swamps containing algae. Larvae have been found repeatedly in rain puddles, the water muddy and without trace of algal growths.

Anopheles quadrimaculatus larva is most like that of punctipennis. The larvae occur in natural collections of water of a more or less [illegible] nature. They often occur in the same locations as punctipennis, but are more addicted to permanent stagnant water, such as the edges of sluggish rivers and marshes containing algae, less to springs and running water, and do not occur in temporary ground pools filled by rains.

The larvae of Anopheles are to be distinguished from Culex and Aedes by the habit of feeding. The two latter genera have larvae with long breathing tubes by which they hang from the surface of the water with the head downward and feed on the life under the surface. Anopheles larvae have very short breathing tubes. They are surface feeders and are held to the surface by the tube and the fan supported abdominal tufts. The head is turned completely over with the mouth uppermost in the act of feeding.

The Anopheles larvae may be partially separated by the following table:

1. Abdomen with five pairs of fan-shaped tufts, the first pair small
---------- (punctipennis Say
(quadrimaculatus Say

Abdomen with five pairs of fan-shaped tufts---2.

2. First and last pair of fan-shaped tufts smaller than the others

----------crucians Wiedemann

Fan-shaped tufts all equal, each element in the tuft with long slender apical portion

----------pseudopunctipennis Theobald

THE PUPAE.

Unlike other insect pupae the mosquito pupae are active and capable of moving rapidly through the water. They depend upon communication with the air for respiration. The respiration takes place through a pair of appendages on the thorax, called the respiratory trumpets. By lashing the pair of chitinous plates at the apex of the eighth segment, called paddles, the pupa can descend rapidly. It rises to the surface as soon as it ceases its efforts. The pupa of mosquitoes is also peculiar in that it possesses eyes, which enable it to see the approach of an enemy and make its escape. Figures of the three genera discussed in the paper are given (figs. 6,7,8).

ADULT MOSQUITOES.

The adult mosquitoes are known to all of us. The males take only vegetable food, but the females also require a blood feed, in many species, before they can oviposit. Various species attack insects, frogs, birds and all types of mammals for their blood-feed. Culex quinquefasciatus feeds at night. Aedes grammeteus in the day time, and the Anopheles during the twilight hours of early morning and evening.

1. Palpus of female as long as the beak (see fig. 13) and the wings brown with yellowish-white spots or markings (5,6,7,8)---Anopheles

2. Palpus of female shorter than beak (see fig. 12) and wings without definite spots or markings-------(Aedes (3)
(Culex (4)

3. A dark brown species with two curved, silvery white lines (resembling an inverted lyre) on top of body. Yellow fever mosquito--Aedes argenteus (Poir.

4. Pale reddish-brown species with top of abdomen much darker and with 5 yellowish-white bands across the top---Culex quinquefasciatus Say.

5. A dark brown species with a vein near the base of the wing yellowish-white and this vein having three distinct dark spots---Anopheles crucians Weid.

6. A dark brown species with the wings mostly brown having a large yellowish-white spot on the front edge of wing towards the tip and a smaller light spot close to the tip. Fringe at the tip of wing dark---Anopheles punctipennis (Say.

7. A species very slightly smaller. Wings clear except along front edge where there are three large yellowish-white spots towards the tip. The third spot is at the tip and the fringe at the tip of the wing is yellowish-white ----Anopheles pseudopunctipennis Theob.

8. A brown species with the wings without pale, conspicuous markings. Wings with four dark gray to black spots on outer half.

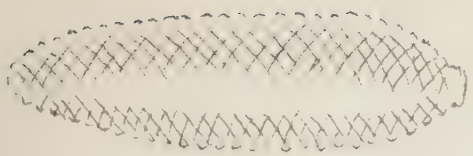
------Anopheles quadrimaculatus. Say.

The yellow-fever mosquito is more definitely marked than any other species of mosquito known. The general color is a dark brown on top of the thorax or back there are two silvery-white curved lines which resemble an inverted lyre.

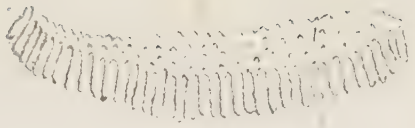
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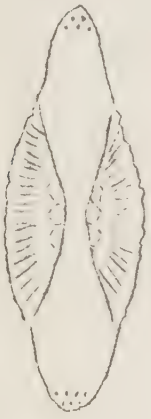
1.



2.



3.



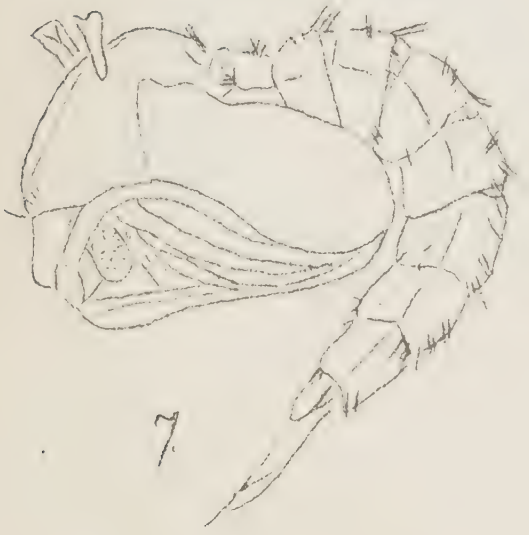
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5.



6



7.



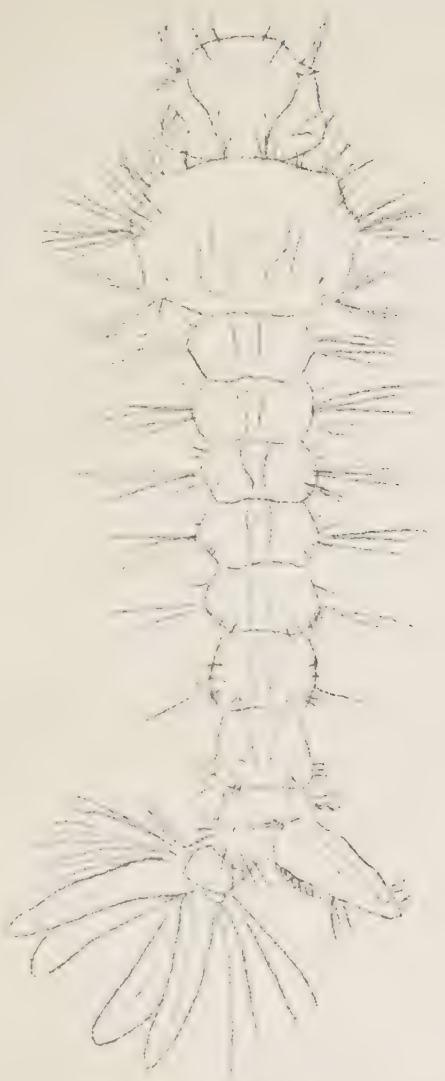
8.

1. Aedes argenteus egg.
2. Culex pipiens egg mass.
3. Anopheles punctipennis egg
4. Anopheles quadrimaculatus egg
5. Anopheles crucians egg.
6 Culex pipiens pupa
7. Anopheles punctipennis pupa
8. Aedes argenteus pupa

a duplicate from Howard, Dyar and Knab.

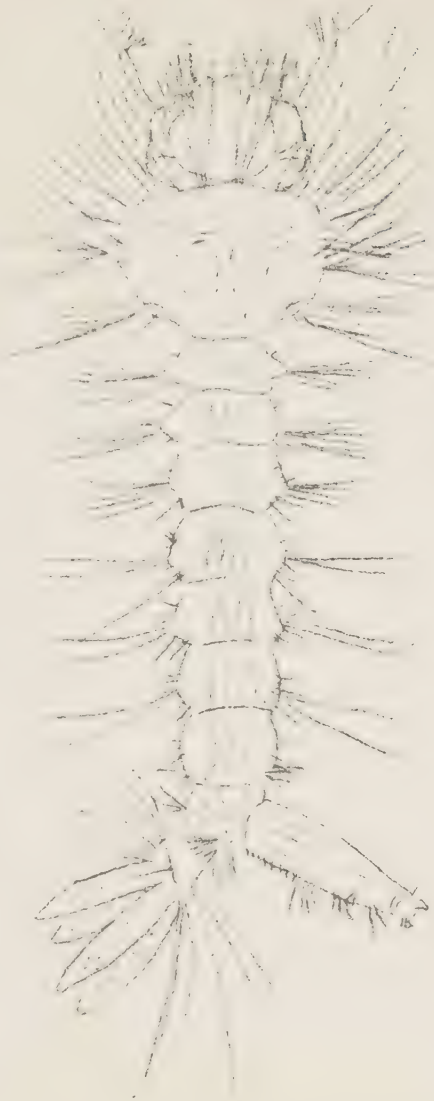
W. Reno

Clades de pentas



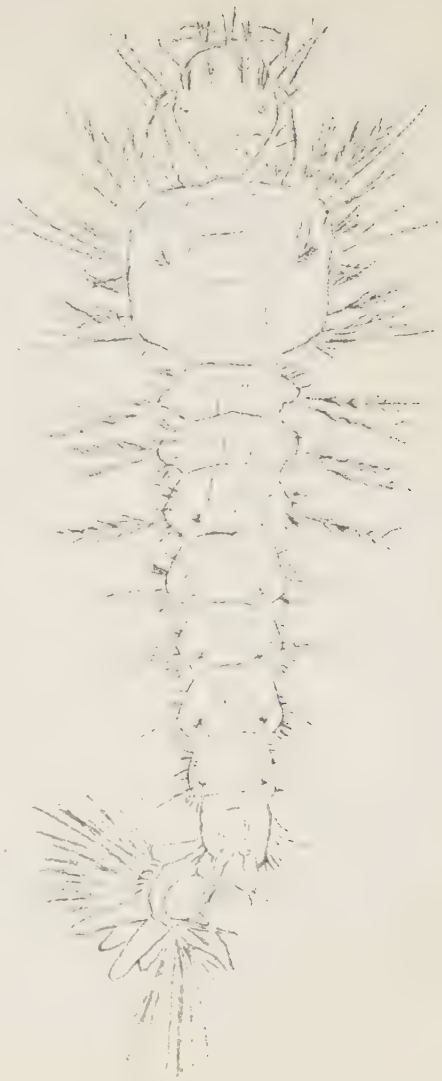
9.

Lucia quinquefasciata



10.

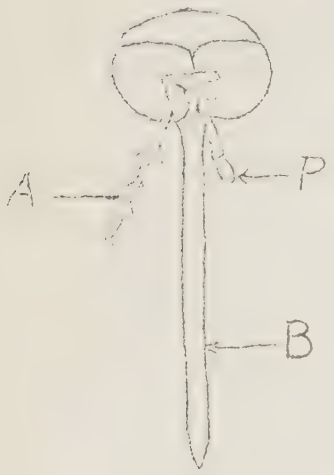
Cryptus [illegible]



11

Types of Mosquito Heads, showing palpal differences.

Females



12.



13.

A = Antenna B = Beak P = Palpus.

BULLETIN No. 213.

The Control of House Flies by the Maggot Trap

By E. N. Cory.



The Maryland State College of Agriculture
Agricultural Experiment Station
COLLEGE PARK, MD.

FEBRUARY, 1918.

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THE MARYLAND STATE COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

Bulletin No. 213 February, 1918

CONTROL OF HOUSE FLIES BY THE MAGGOT TRAP METHOD

By E. N. Cory.

INTRODUCTION.

In the late spring of 1914 a practical test of the maggot trap, as devised and tested in an experimental way by R. H. Hutchison,[1] was planned and begun in cooperation with the Bureau of Entomology, U. S. Department of Agriculture.*

One trap was constructed at the College barn, operated during the season and the results published by the Bureau of Entomology.[2] The results were so encouraging that it was decided to increase the scope of the test to include two traps at the Experiment Station. This was accordingly done in 1915 and continued through 1916 and the results of the three years' work are herein reported. Details of the work were attended to by Mr. Max Kisliuk, a graduate of this College, in the employ of the Bureau of Entomology.

Bulletin No. 200 of the U. S. Department of Agriculture prepared by Mr. Hutchison gives the essential data in regard to the first year's work and has been freely used, in many parts verbatim or with slight changes.

Importance of House Fly Control.

Indisputable evidence, has demonstrated that the common house fly (*Musca domestica* Linn.) is largely responsible for the dissemination of typhoid fever, and other intestinal diseases. It is also an important carrier of tuberculosis, visiting sputum of tubercular

1 References are to literature cited at the end of this bulletin.

* This project was undertaken in cooperation with the Bureau of Entomology, U. S. D. A. The Maryland Agr. Exp. Sta. furnished the facilities and the Bureau furnished the man to make the records. By the terms of the agreement the results were to be published jointly or independently. It was decided that the first year's work be published by the Bureau only and the results of the three years' work are herein reported, combining the first year's report Bul. No. 200, U. S. D. A., B. of E., with the results for the 2nd and 3rd years.

patients and ingesting tubercular bacilli and subsequently voiding the bacilli on human food in the form of "fly specks" or excreta.

Therefore on the above indictment alone, not to mention the fact that they are a filthy nuisance, the importance of reducing the number of flies is evident.

To make this reduction in the most effective and economical way, efforts must be centered in reducing the number of larvae, the potential flies, because efforts directed against the adults are usually ineffective as the eggs frequently have been deposited before the flies are captured.

Description and Life History of the House Fly.



Fig. 1.—The house fly, Musca domestica Linn. Note the broad tip of the proboscis.

The house fly (Fig. 1) is about 3/8 inch long, gray above, striped with black on the thorax, dirty white to straw color beneath with black legs and feet, covered with minute hairs. Its mouth parts are formed for lapping. Another fly, the stable fly (*Stomoxys calcitrans* Linn.) which is very similar in appearance, has piercing mouth-parts (Fig. 2) and its presence in houses is responsible for the widespread belief that the house fly can pierce the skin.



Fig. 2.—The stable fly, Stomoxys calcitrans Linn. Note the sharp proboscis extended forward.

The house fly deposits its eggs to the number of 60-100, preferably on fresh horse manure. These eggs hatch in from 8 to 40 hours under favorable temperature conditions. The larval stage may occupy from 5 to 26 days dependent upon temperature, moisture and an abundance of the favored food. The pupal stage or period during which the larva changes from a white maggot to the adult winged insect may require 4 to 21 days. The shortest period is therefore 9 1/3 days for the complete life cycle from the egg to the adult insect. Egg laying begins about 10 days after emergence.

Efforts to kill the larvae must, therefore, be especially efficient within the period of 9 days and must extend over a sufficient period to insure the destruction of all larvae that might take a longer period for their development.

Previous remedial measures have for the most part consisted of treating the manure with various materials with the hope that they would prove efficient "larvicides". However, the work has been largely ineffective, due to the difficulty of thorough treatment; or, uneconomical, due to the prohibitive cost of materials and labor or the injurious effect on the fertilizing value of the manure by the larvicides.

Local Conditions with Regard to Fly Prevalence and Breeding Places.

The college is somewhat isolated by its position on a hill and separated a considerable distanc from any nearby stables. On the

accompanying map (Fig. 3), which has been adapted from a map of the Geological Survey, is shown the topography of the surrounding section. The location of only two of the college buildings is given, viz., the college kitchen (K) and the stable (S). The college kitchen, by reason of odors from cooking and the presence of garbage kept in iron pails just outside the door, attracted large numbers of flies. However, no flies were breeding out from this garbage, for the reason that it was entirely removed every two or three days and taken to a near-by farm, where it was fed to hogs.



Fig. 3.—Map of vicinity of the Maryland Agricultural College showing the location of the college kitchen (K), the stable (S), and the proximity of other breeding places of flies (A, B, C, D, etc.). (After Hutchison, U. S. D. A. Bull. 200).

The breeding ground nearest to the kitchen was the pile of manure heaped just outside the college stable. This is nearly 200 yards northwest of the kitchen. It is probable that a large majority of the flies at the kitchen came from this source. Upon examination at various times during June and July, 1914, the fresher portions of this heap were always found heavily infested with larvae. Puparia were also found in great abundance in the loose soil and in the manure at the periphery of the pile. Three horses were kept in this stable, and two of them were standing in the stalls during the greater part of each day. Flies were also very numerous in and about the stable, and during the day the horses were continuously tormented by them.

With the exception of the college stable, there were no breeding

places for flies within 400 yards of the kitchen. The stable, indicated by the letter S on the map, is approximately 400 yards from the kitchen and about 200 yards from the college stable. Other stables are located some 400 to 500 yards west of the college stable, the distance from the kitchen being about 200 yards greater.

Another extensive breeding place was found in the large collections of manure at the barns of the experiment station, located about 700 yards northeast of the college. This is indicated on the map by the letter A.

PART I.

Plan of First Experiment.

During the season of 1913 experiments were carried out independently by Levy and Tuck at Richmond, Va.,[3] by C. G. Hewitt[4] at Ottawa, Canada, and by R. H. Hutchison at Arlington, Va.,[1] and New Orleans, La., all of which demonstrated a migratory habit of house fly larvae just before pupation. It was found easy to trap them at this particular stage of their development, and experiments with small maggot traps showed that as high as 98 or 99 per cent of the larvae could be caught.

It was planned therefore, to construct a maggot trap large enough to take care of the entire manure production at the college barn, with the idea that if the trap proved effective there should appear a marked decrease in the prevalence of flies, not only at the barn, but at the college kitchen. To determine whether or not the trap was effective the following three lines of observation were undertaken: (1) By collection and careful estimation of the larvae caught by the trap and subsequent search for puparia in the manure, to get some idea of the percentage destroyed; (2) by making numerous fly counts during the season to find out whether the prevalence of flies at the kitchen and stable were decreased; and (3) to determine whether any of the flies at the college came from near-by breeding grounds (A, B, C, etc.) other than the manure heap at the college stable.

The Maggot Trap.

The maggot trap used in this experiment was designed and constructed as follows: First, a concrete floor was prepared 22 feet long and 12 feet wide. Around this floor was a rim or wall of concrete 4 inches high and 4 inches thick. An outlet pipe 4 inches in diameter was fitted in one corner toward which the floor sloped a little so that water would run out easily. Water was retained in the basin by stopping the pipe outlet with a plug of soft wood. The pipe outlet led to a small cistern 5 feet square and 4 feet deep. the walls and floor of which were made of concrete. A wooden platform 20 feet long and 10 feet wide, supported on legs 1 foot high was constructed on the basin. The framework of the platform was

made of 2 by 4-inch studding. There were 6 of these pieces running lengthwise 2 feet apart, and one fastened across each end. Each of the long pieces was supported on four legs set at intervals of nearly 7 feet. Across the top of the framework were nailed strips 10 feet long by 1 1/4 inches thick and 1 inch wide. These strips were nailed 1 inch apart. Fig. 4 shows most of the details of construction. Fig. 5 gives another view, including the outlet pipe, consisting of 4-inch terra cotta and the pump in place over the cistern. On account of various obstructions it was necessary to place the cistern some distance away from the trap, although as will be pointed out later, it is desirable to have the cistern close to the trap, and the pump so arranged as to return the contents of the cistern to the manure heap on the platform. The initial cost is about $45.00 for a single trap. Two traps may be constructed for about $75.00.

Plan of the Experiment in 1914.

The maggot trap was put into operation on July 25, 1914. On this date the manure pile which had accumulated in front of the barn during June and July was hauled away and spread on the fields, so that, beyond the hatching out of the pupae and larvae already present, it ceased to exist as a breeding ground for flies. On and after July 25th each day's production of manure was heaped on the platform. Beginning at the end farthest from the barn door, the manure was piled up to a height of from 3 1/2 to 4 feet. The heap was maintained at about this height, and with the daily additions it kept increasing in length. Figs. 4 and 5 show the appearance of the heap after a little more than four weeks' accumulation. The platform was found large enough to hold a little more than two months' production of the total manure produced by three horses. Each day, after the addition of manure and litter from the stable, the manure on the platform was sprinkled with enough water to moisten it thoroughly without causing any leaching. Water was run into the concrete basin below the platform, so that the floor beneath the manure was covered to a depth of 1/2 inch in the shallowest part. Larvae migrating from the manure dropped into the water below and were drowned.

At least once a week, and sometimes oftener, the water was drawn off from the basin into the cistern and the floor was washed clean by a strong stream of water. The larvae which had fallen into the water, together with the debris which had sifted through the platform or fallen from the sides, were collected at the cistern end of the outlet pipe in a strainer. The matter thus retained in the strainer was then spread out on a smooth concrete surface near by, and the number of larvae present was carefully estimated. The outlet was then plugged, and the basin again partly filled with water by pumping back what had run into the cistern.

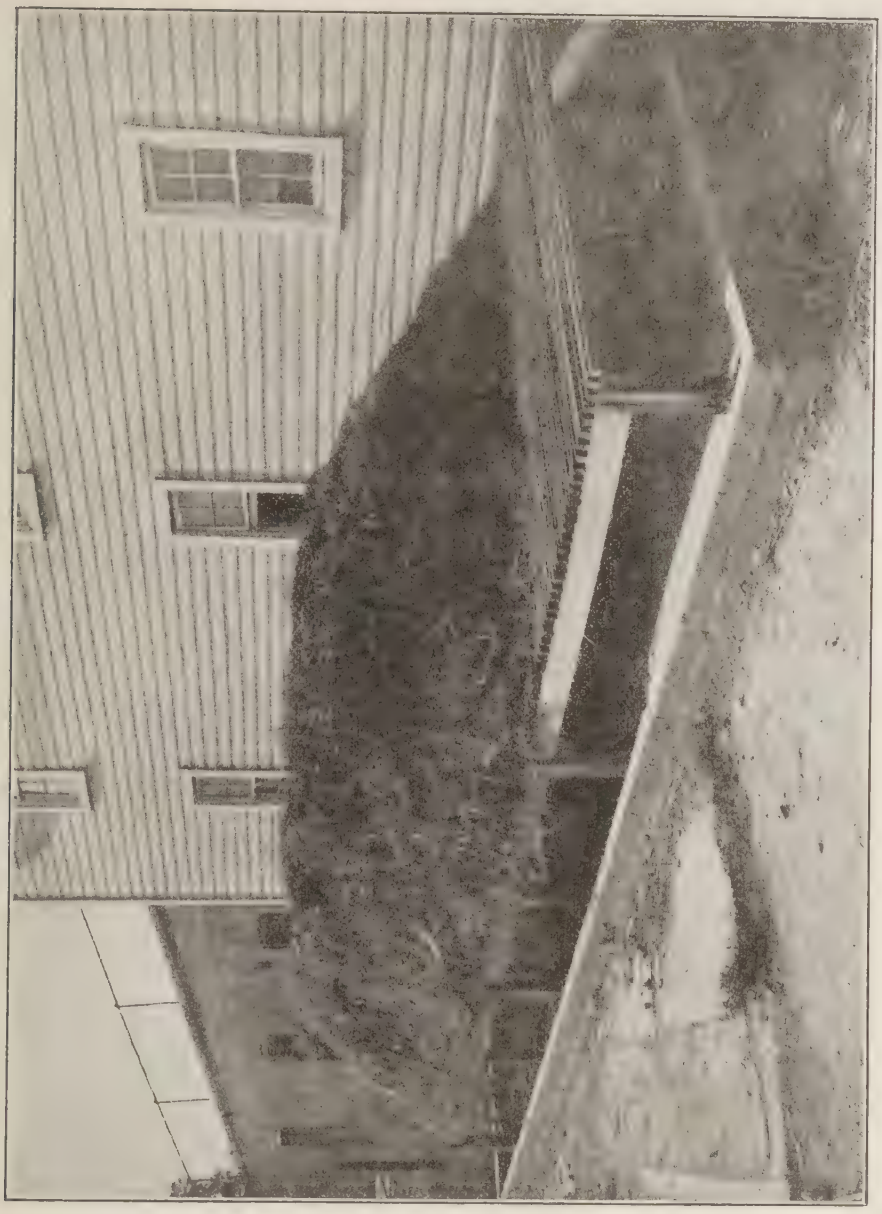


Fig. 4.—View of a maggot trap, showing the concrete basin containing water in which larvae are drowned, and the wooden platform on which manure is heaped. (After Hutchison, U. S. D. A. Bull. 200).

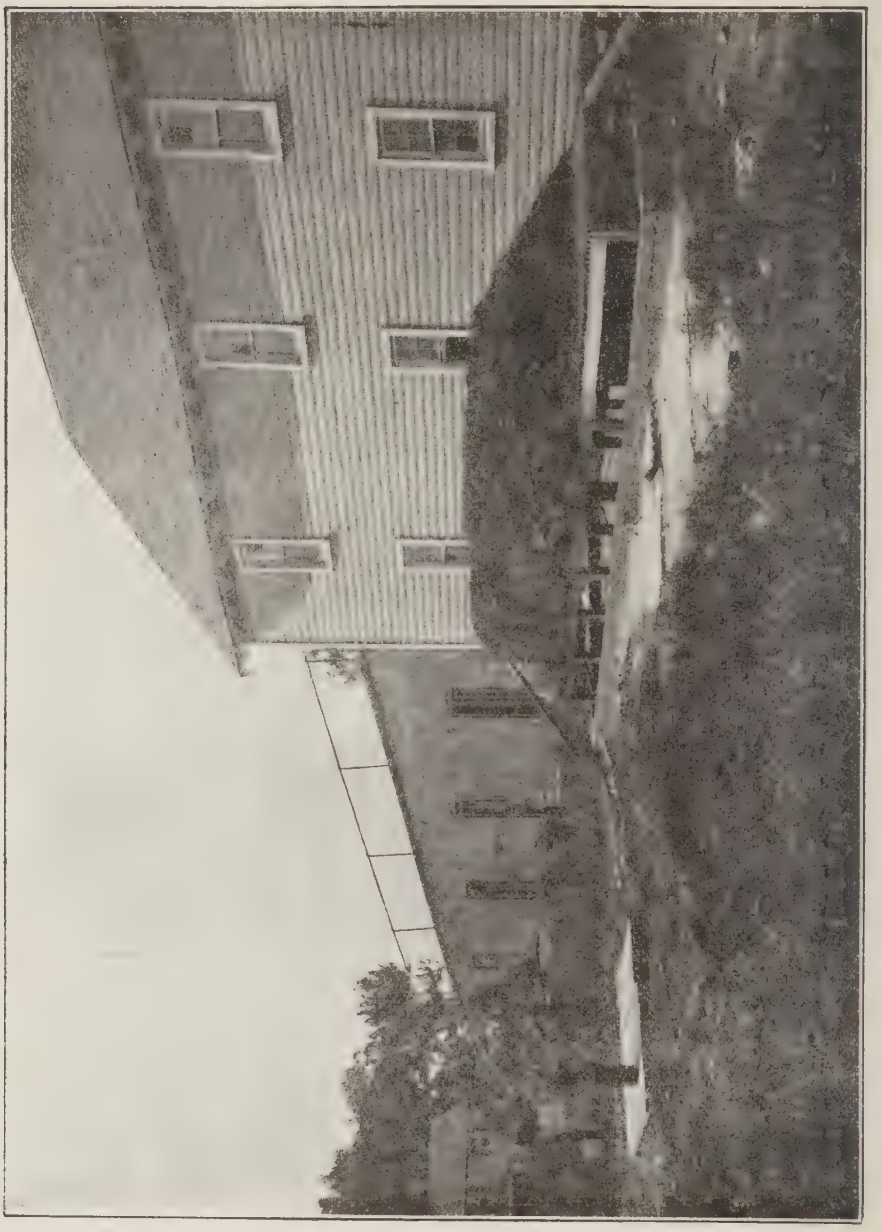


Fig. 5.—Another view of the trap shown in Fig. 4, sh owing the pipe leading to the small cistern, and the pump used to force water back to the concrete basin. (After Hutchison, U. S. D. A. Bull. 200).

The Percentage of Maggots Destroyed in 1914.

Without going into details of the weekly or bi-weekly counts, it will be enough to state that during the period from July 25th to October 1st a total of about 112,000 dead larvae was collected in this way. But this number does not represent all that dropped out of the manure into the water below. A flock of young turkeys roamed at large during the summer over the college grounds and adjoining fields. Having once found the maggot trap they made frequent visits and were seen to devour the larvae with great avidity, sometimes completely clearing the floor except where the water was more than 2 or 3 inches deep, or when it was so badly discolored as to conceal the larvae. Sparrows also were seen frequently on this floor, but one could never get close enough to see whether they actually devoured any larvae or not. It is more than likely that they did. The actual number of larvae which were destroyed by the maggot trap was undoubtedly much greater than 112,000.

After October 1st all the manure on this platform was examined for puparia. The manure was thrown off, a few bushels at a time, and very carefully examined, all straw being shaken out and all solid parts being broken up. A few scattered puparia were seen in various parts of the heap, but in only two spots were they to be found in the characteristic cluster or "nests", which can be found so readily at the edges of manure piles on the ground. These two nests were found at the end of the pile where the most recent addition had been made. The manure at this end had not been sprinkled with water after the day it was put on. Failure to keep this moist as long as larvae were present is the probable explanation of the pupation in this part. One nest contained about 400, and the second about 700 puparia. Allowing for some that may have escaped notice, the number of puparia may be given in round numbers as 1,500. No larvae whatever were found in any part of this heap, the oldest part of which had been on the platform for two months, and even the freshest portion of which had been standing for at least 10 days before it was examined. If, then, 1,500 represents the total number which pupated in the manure and 112,000 the number which were destroyed by drowning, it shows a percentage destruction of about 98.5 per cent of the possible total. This is illustrated in Fig. 6. Taking into account the larvae devoured by turkeys, etc., it is probable that the effectiveness of the trap could be rated as above 99 per cent.

The claim has been made that manure will be practically free from maggots after standing 10 or 12 days.[3] Special attention was given

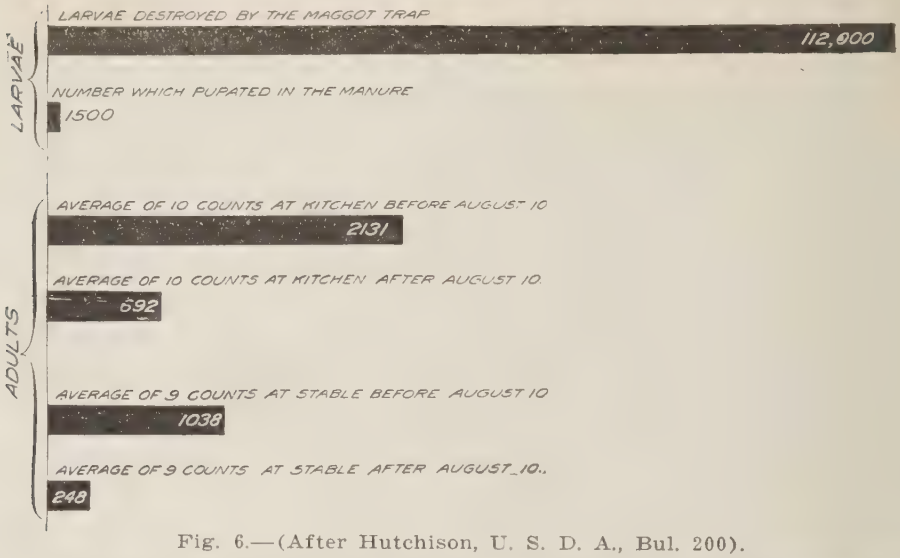


Fig. 6.—(After Hutchison, U. S. D. A., Bul. 200).

to this point during the course of the experiment, and all observations tended to support the claim. Moreover, there was no evidence that larvae ever migrated from the fresher portions of the manure to the older parts to pupate. That old manure does not serve as a breeding place for flies is a point that deserves some emphasis entirely aside from its bearing on the practical use of the maggot trap. The explanation is probably to be found in the changes which take place in the manure heap during storage. As the pile stands it settles considerably, with a consequent decrease of air spaces, and, especially if watered, air does not penetrate far below the surface. Deherain and Dupont[5] have shown that in manure well heaped so that air cannot penetrate readily, the confined gases consist largely of carbon dioxide and methane, and that oxygen is not found except near the surface. It may well be that the lack of oxygen and the abundance of carbon dioxide render old manure unfavorable for the breeding of flies. It may also be that the composition of the gases in the manure is one of the factors which influence migration and the choice of a place for pupation.

Effect on the Fly Prevalence at the Stable and Kitchen in 1914.

The influence of the maggot trap on the number of flies at the stable and the kitchen is shown by the fly counts represented graphically by Fig. 7. In taking the counts, "tanglefoot" sticky fly paper was used. The papers were exposed for 24-hour intervals and counted immediately at the end of that period. Fig. 7 is a graphic representation of these series of counts at the stable and kitchen. In each case the number given is the total caught on two papers exposed in the same way on top of the garbage pails, and at the stable. Where

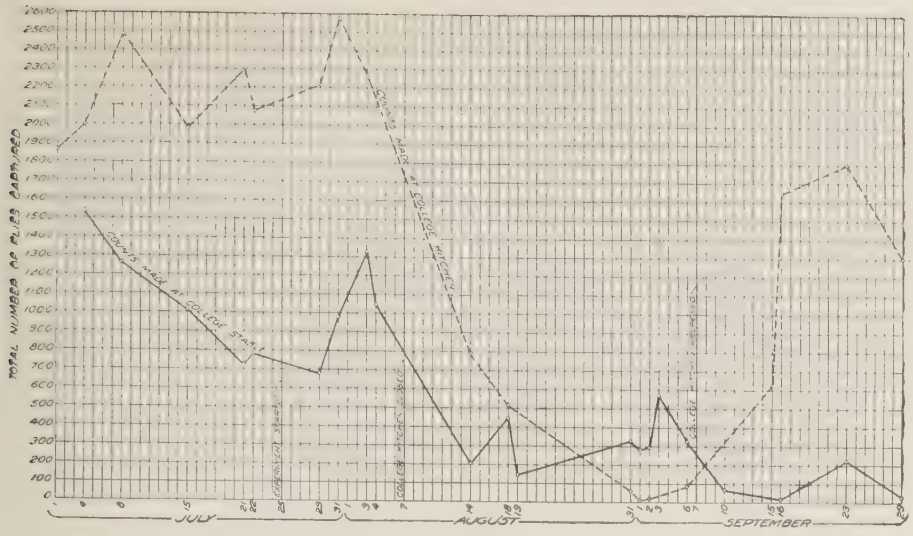


Fig. 7.—Diagram showing number of flies caught in 1914 during the operation of the maggot traps. The broken line connects series of fly counts at the garbage pails near kitchen; the solid line those at the stable. (After Hutchison, U. S. D. A. Bull. 200).

one paper was put on the floor just outside the door and the second just inside the door, which faces the east. On several occasions papers were exposed, but the counts are not given in the diagram for the reason that a shower of rain or a strong wind spoiled some of the papers. The numbers which are plotted are those obtained on clear, warm days, on which the climatological conditions were nearly the same except for the direction of the wind. This will account for the irregular time intervals between the successive counts.

A study of the fly counts shown in Fig. 7 reveals that there was a decided drop in the number of flies both at the kitchen and stable very shortly after the maggot trap was put into operation. Assuming that all the flies at the stable and kitchen at the time the experiment began (July 25th) were freshly emerged and that they would all die off within three weeks (there is some evidence that flies seldom live longer than this in midsummer), one would expect to find a reduction in the number of flies about August 10 or 12. Although the counts fluctuate considerably after this date, in no case do the highest counts rise to the level of the lowest counts made before August 10th.

In one respect these counts hardly give a fair indication of the effect of the maggot trap, for the reason that the college kitchen was closed from August 7th to September 7th. It will be seen that flies almost completely disappeared from the kitchen during the latter part of August, but as soon as the garbage pails were again in use the fly counts go up fairly high, although not as high as the lowest count at this place before the experiment started. It is interesting

to note that while the kitchen was closed the fly counts at the stable were somewhat increased and that after the kitchen reopened the flies almost disappeared from the stable. Taking the counts at the kitchen, we find that the average of the 10 counts before August 10th is 2,131, while the average of the 10 counts after August 10th is 692, an average reduction of 67.5 per cent. At the stable the average of 9 counts before August 10th is 1,038, and the average of 12 counts after August 10th is 248, an average reduction of 76 per cent. (Fig. 6).

This low percentage as compared with the almost total destruction of maggots may be accounted for by the presence of other breeding places which will be considered under another heading.

A few flight experiments with marked flies were carried out during the season, not with the idea of determining the range of flight, but merely to make sure whether or not flies from these various breeding places found their way to the college stable or kitchen.

First, about 600 recently emerged flies were thoroughly dusted with finely powdered red crayon and liberated on August 31 at a point near the stable indicated by the letter B (Fig. 3). The point of liberation was about 400 yards west of the college stable and perhaps 500 yards from the kitchen. In spite of the presence of several houses and stables in the immediate vicinity, some of these marked flies found their way to the college barn. Here two of this lot were recovered within the first 24 hours, and a third one during the third 24-hour period. That no flies were recovered at the kitchen is to be explained by the fact that the kitchen was closed and there was nothing there to attract flies.

A second lot of about 500 flies, sprayed with rosolic acid, were liberated at the dairy barn (A) of the experiment station, 700 yards due east from the college stable. The distance from the kitchen is slightly less. They were liberated at 3.30 P. M., September 1st. On September 3rd two marked flies were found on papers exposed at the dairy barn, but none was recovered at the college stable or kitchen. A strong southwest wind was blowing at this time and may have had some influence on the result. It is hardly to be doubted that when the kitchen is in use numbers of flies from this source are attracted to it. The manure pile back of the dairy barn was found to be heavily infested at all times during the summer, and flies bred out here by the thousands.

In a third experiment about 800 flies marked with powdered red crayon were liberated on September 15 at the stable marked by the letter C (Fig. 3). Within the first 24 hours, 11 marked flies were recovered on fly papers at the garbage pails at the kitchen, and two more during the second 24-hour period after liberation. No marked flies were recovered at the college stable in this experiment. The kitchen was in use at this time, and it must be considered significant that the flies were recovered only at the kitchen, although they had to pass right by the stable.

The same thing happened on September 22. A lot of about 600 flies sprayed with rosolic acid had been liberated on September 21 near the stable marked on the map by the letter D (Fig. 3). None of these were recovered at the college stable, but three were found within the first 24 hours on papers exposed on the garbage pails.

These few experiments indicate that a large number of the flies which congregate at the college kitchen and stable come from nearby breeding grounds other than the manure pile at the college barn. And it may be said that a reduction of from 67 to 76 per cent in the average number of flies, in spite of the proximity of these other breeding places, speaks well for the efficiency of the maggot trap.

The behavior of the horses standing in the stalls was also a fairly good index of fly prevalence in the stable. The horses were constantly tormented during June and July. During the day the stamping of feet and switching of tails was incessant. After the maggot trap had been in operation for some time there was a noticeable change. The horses stood much more quietly, and their efforts to get rid of flies were less continuous.

PART II.

Modification of the Traps in 1915.

During the summer of 1915 two traps were constructed at the experiment station to care for all the manure collected from the horse, cattle and pig barns. These traps were modified slightly as the experiences of the previous season with the original trap dictated. Further modifications that increase the efficiency of the trap will be indicated later.

The two traps were of the same dimensions as the first with a cistern located between them, (Fig. 8) in order that both traps could be drained into it. The traps were placed 10 feet apart so that a wagon could be loaded from either side.

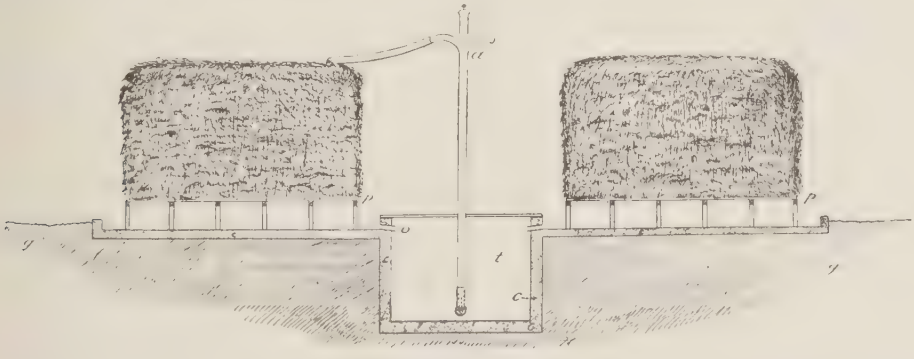


Fig. 8.—Cross-section of an arrangement suggested for use where manure production is large. Slatted sides should be used. a, pump; c, concrete floor and walls of cistern; o, outlet pipes leading from floor of maggot trap to cistern; p, platform maggot trap; t, cistern for liquid manure; g, ground level. (After Hutchison, U. S. D. A. Bull. 200).

Slatted sides 3 ft. high were built around 3 sides of each trap. These sides helped to hold the manure on the platform. Each trap was sufficient in size to retain the manure from an average of 14 horses, 28 cows (in the barn about 3 hours daily) approximately 20 pigs and 4 bulls for a period of two weeks.

Plan of the 1915 Experiment.

The work of 1915 included the trapping of maggots at the college barn trap and at the two traps at the Experiment Station; the estimating of the number of maggots caught at each; the examination of the manure at the time of removal for puparia and the catching of flies at the college kitchen, the college barn and the experiment station to ascertain the relative reduction in the adult flies. The method used in estimating the number of larvae was to weigh a representative sample of the maggots caught after removing as much debris as possible; counting the maggots in the sample; weighing the total catch and calculating the total number of maggots. The same procedure was adopted in estimating the puparia. In 1916 the same method was used in estimating the fly catch.

The Percentage of Maggots Destroyed in 1915.

Due to labor shortage, the station traps were not ready for use until Aug. 16th. On this date trap A was started. On Aug. 30th trap B was started when trap A was loaded to capacity and operating to catch the late migrating larvae. Meanwhile trap C at the college barn was in full operation, having been started on June 6th. Manure was piled on trap A for two weeks, and allowed to remain for two weeks longer. Meanwhile trap B was started two weeks after trap A, as that was the time required to fill a trap to capacity. At the end of the fourth week trap A was cleared and started anew. At the end of the sixth week trap B was cleaned, alternating thus throughout the season.

Table I shows the number of larvae caught and destroyed, the number of puparia found when each trap was cleaned, including the number of larvae remaining, (considered as potential puparia) and the percentage of larvae destroyed.

Reference to the counts which were made at approximately weekly intervals shows that the highest catches were made in almost all cases, at the end of the week following the cleaning of the trap and the renewal of its operation. This is not true for the trap C which was cleaned at greater intervals because the amount of manure on the trap at the end of a week following cleaning was not sufficiently large to warrant removal. The highest catch for one week, 125,000, is found in the records of trap A for the week ending September 21st.

The total catch for trap A for the period from August 10th to November 10th was 584,000; 102,800 puparia were estimated with a resultant mortality or effectiveness in reducing the number of larvae of 84.2%. The total catch of trap B for the period from August 30th

to November 27th was 391,700; the total puparia remaining in the manure was 47,800, giving an effectiveness of 89.1%. Trap C operated over a longer period caught 242,620 maggots; 3,900 puparia were found at the cleaning times giving an effectiveness of 98.6%. The apparent greater effectiveness of this trap may be due to the fact that the trap was cleaned at longer intervals, thus allowing for the emergence of many of the flies from larvae that might have succeeded in pupating. On the other hand the average catches per day for traps A, B and C which were 6,952.4, 4,502.2 and 1,956.6, respectively, show relatively great efficiency for trap C when the amount of manure on each trap is considered. Nearly 5 times as many horses were stabled where A and B traps were in operation as where C was operated. The total maggots caught was 1,372,820; 154,700 puparia remained, giving a season's effectiveness in terms of maggot mortality for three traps of 89.8%.

TABLE I.

RECORD OF TRAPS IN 1915.

TRAP A			TRAP B			TRAP C		
Started 8/16/15	Larvae	Puparia	Started 8/30/15	Larvae	Puparia	Started 6/6/15	Larvae	Puparia
8/24	100,500		9/7	108,000		6/24	6,500	
8/31	97,500		9/14	105,000		6/24	2,770	
9/7	8,000		9/21	4,000		7/3	20,000	
9/11	(c) 2,000	30,000	9/25	(c) 2,000	31,000	7/10	14,500	
9/21	125,000		10/5	76,000		7/17	25,500	
9/28	106,000		10/12	59,000		7/24	6,700	
10/3	57,000		10/23	8,000		7/31	20,000	
10/9	(c) 12,000	70,300	10/26	(c) 500	16,600 (b)	8/7	14,500	
10/19	49,000		11/2	10,000		8/10	(c) 300	2,600
10/26	21,000		11/10	16,500		8/14	200	
11/2	4,000		11/16	1,500		8/21	26,500	
11/10	(c) 2,000	2,500 (a)	11/23	1,000		8/28	22,000	
			11/27	(c) 200	200	9/4	15,000	
						9/11	15,000	
						9/18	7,000	
						9/25	17,500	
						10/2	12,750	
						10/9	9,000	
						10/10	(c)	1,300
						10/16	300	
						10/23	6,000	
						10/30	(c) 400	
Total.....	548,000	102,800	Total.....	391,700	47,800	Total.....	242,410	3,900
Mortality 84.2%			Mortality 89.1%			Mortality 98.5%		

a—2,000 larvae, remaining included in this total.
b—4,000 larvae, remaining included in this total.
c—Cleaned.

Effect on the Fly Prevalence at the Stable, Kitchen and Experiment Station in 1915.

Tanglefoot fly papers were exposed at the stable, kitchen and dairy barns to ascertain the relation between the destruction of maggots and the prevalence of flies. These records were carefully kept even though the traps at the Experiment Station were not put into operation until after the middle of August, thereby making it practically impossible to judge the reduction in flies. However, it was thought that some ideas as to the factors governing fly prevalence might be deduced. Tanglefoot papers proved a failure and were discontinued in the 1916 tests.

The records printed as Table II show that there are undoubtedly distinct periods when fly prevalence is always at its greatest. These periods, near the last of July, August and September and to a less degree the last of June, mark the greatest incidence of the several broods. Undoubtedly the generations overlap considerably and spring weather conditions in a large measure determine the degree of overlapping. Cold wet springs, retard the gradual development and give rise to abundant breeding when warm settled weather finally comes. In such a season the broods will be more distinctly marked than when the reverse weather conditions have prevailed. May, 1915, was on the whole cool and cloudy with the precipitation slightly above the average. The records reflect this condition. The emergence of the several broods also influences the counts so that this method of determining fly prevalence is faulty. The counts do not give either positively or negatively constant results.

Table II.

Effect of Maggot Trap on the Prevalence of M. domestica in 1915.

Date	KITCHEN		STABLE		DAIRY	
	Total Flies	M. domestica	Total	M. domestica	Total	M. domestica
5/19/15	10	1	49	33	24	5
5/22/15	31	11	53	42		
5/28/15	41	27	46	36		
5/31/15	27	13	43	18	22	8
6/ 5/15	123	30	16	3	62	13
6/ 7/15	10	7	22	12	16	6
6/ 8/15	4	1	104	65		
6/11/15	53	12	119	33	9	2
6/19/15	217	93	93	29	19	14
6/24/15	54	24	68	29		
6/26/15	123	76	143	102	92	69
6/29/15	113	63	587	482	66	45
7/ 3/15	90	65	435	275	198	173
7/ 6/15	173	127	97	87	350	331
7/10/15	196	167	106	102	287	246
7/13/15	201	92	492	485	69	67
7/17/15	552	483	308	279	189	134
7/20/15	590	574	1,355	1,320	750	726
7/24/15	574	549	667	657	815	807
7/31/15	285	366	389	367	315	290
8/ 3/15	649	630	287	272		
8/ 7/15	41	35	346	333	333	312
8/10/15	334	218			887	848
8/13/15			692	650		
8/14/15	71	63	223	311	645	613
8/17/15	90	55	205	181	747	703
8/21/15	48	33	190	170	123	116
8/24/15	28	23	261	242	412	398
8/28/15	15	8	190	113	42	14
8/31/15	76	59	136	83	1.547	1,472
9/ 4/15	41	29	212	170	947	901
9/ 7/15	17	5	138	138	260	239
9/11/15	31	22	113	110	80	71
9/14/15	19	11	153	146	176	170
9/18/15	875	804	295	262	464	418
9/21/15	695	652	658	635	468	447
9/25/15	670	643	354	255	412	374
9/28/15	107	98	207	166	1,355	1,189
10/ 2/15	425	383	282	65	797	662
10/ 5/15	288	211	224	118	335	288
10/ 9/15	17	11	9	2	71	53
10/12/15	92	77	153	41	784	722
10/16/15	30	21	47	31	19	7
10/19/15	236	204	174	31	747	675
10/23/15	12	6	97	32	281	238
10/26/15	148	100	369	102	626	534
10/30/15	42	29	36	11	77	21
11/ 2/15	36	29	65	18	269	199
11/ 6/15	5	0	2	1	41	17
11/10/15	104	46	101	5	158	66
11/16/15	0	0	0	0	0	0
Totals.....	8,758	7,369	11,521	9,150	16,376	14,712

Percentage of Maggots Destroyed in 1916.

Trap A was started June 22nd. Trap B was started June 15th. Trap C developed cracks in the concrete floor which were no sooner, apparently made water-tight, than other leaks were discovered so

that it was in use only at irregular intervals. Therefore the records from trap C are not herein considered.

The catches of maggots in each of these two traps were astounding, running as high as 801,995 per week, (August 3rd in trap A). Contrary to the experience of the previous year, the greatest mortality did not follow immediately after cleaning but the records show a gradual increase and subsidence in the catches as would be expected.

Trap A caught 5,516,684 maggots; 52,000 puparia were found in the manure at cleaning times, giving a mortality record of 99.06%. Trap B caught 4,147,596 maggots; 20,542 puparia remained at cleaning times giving a mortality of 99.2%. The total maggots captured during the summer was 9,664,280. Only 72,542 puparia remained in the manure. This gives a mortality percentage of 99.2%.

TABLE III.

TRAP A			TRAP B		
Started 6/22/16	Larvae	Puparia	Started 6/15/16	Larvae	Puparia
7/6	754,500		6/22	(b)	
7/17	77,175		6/29	353,400	
7/20	(c) 2,000	2,500	7/8	(c) 1,000	1,000
7/27	370,912		7/13	122,880	
8/3	801,995		7/24	779,035	
8/7	548,555		7/31	166,963	
8/14	671,385		8/3	(c)677,343	15,000
8/17	(c) 3,000	12,000	8/7	142,122	
8/21	20,500		8/14	671,385	
8/28	626,010		8/21	81,478	
9/6	699,832		8/28	137,500	
9/11	45,320		8/31	(c) 1,000	15,900
9/14	(c)	25,500	9/5	3,000	
9/18	588,500		9/11	101,790	
9/29		12,000	9/18	588,500	
10/2	286,000		10/2	180,000	
10/9	21,000		10/9	90,200	
			10/12		12,142
Total...	5,516,684	52,000	Total...	4,147,596	30,542
Mortality 99.06%			Mortality 99.2%		

c—Cleaned.
b—Maggot count lost as excessive rains prevented cleaning of basin and pumping out of cistern. Cleaned June 22nd.
Trap C not operated continuously.

EFFECT ON FLY PREVALENCE AT THE STABLE, KITCHEN AND EXPERIMENT STATION IN 1916.

"Perfect" fly traps (Fig. 9, baited with soft banana) were substituted for Tanglefoot paper in taking the records for this year. These proved to be much better than the fly paper but the method is still

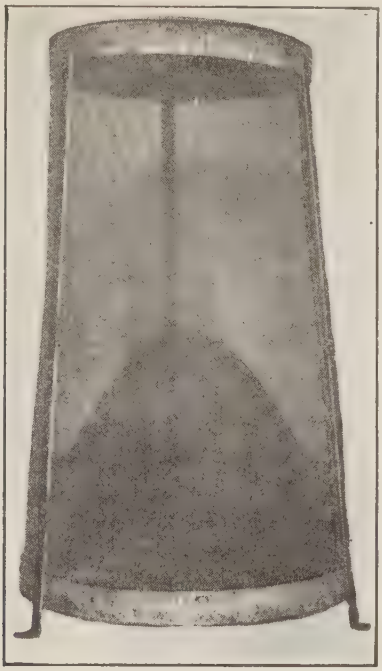


Fig. 9.—"Perfect" fly trap, with a day's catch of flies inside.

faulty because there are so many factors not governable, that are sources of error, the results cannot be interpreted properly. The graph, Fig. 10, shows the relation of the fly prevalence here to that at the Government Experiment Station at Bethesda where no maggot traps were in use.

There is a marked decrease in the fly count at the kitchen after an interval of approximately three weeks from the date on which the last station maggot trap was put in operation and a subsequent decrease and flattening of the curve.

The count at the Experiment Station was low almost throughout the season, the only high point being reached by the late July brood but in no case did the highest point in the counts after the operation of the maggot traps, reach the highest level of the counts at Bethesda. The conditions with respect to fly breeding at Bethesda and the Experiment Station were approximately equal except for the operation of the maggot traps at the latter place. Late July and August and mid-September broods are shown in the graph.

The fly counts at the college barn were extremely low throughout the season. As the maggot trap there was not in operation except at intervals, the low records cannot be attributed to the effect of the maggot trap. The only high point at the College barn was reached by the late September brood which coincides with the high point in September at Bethesda.

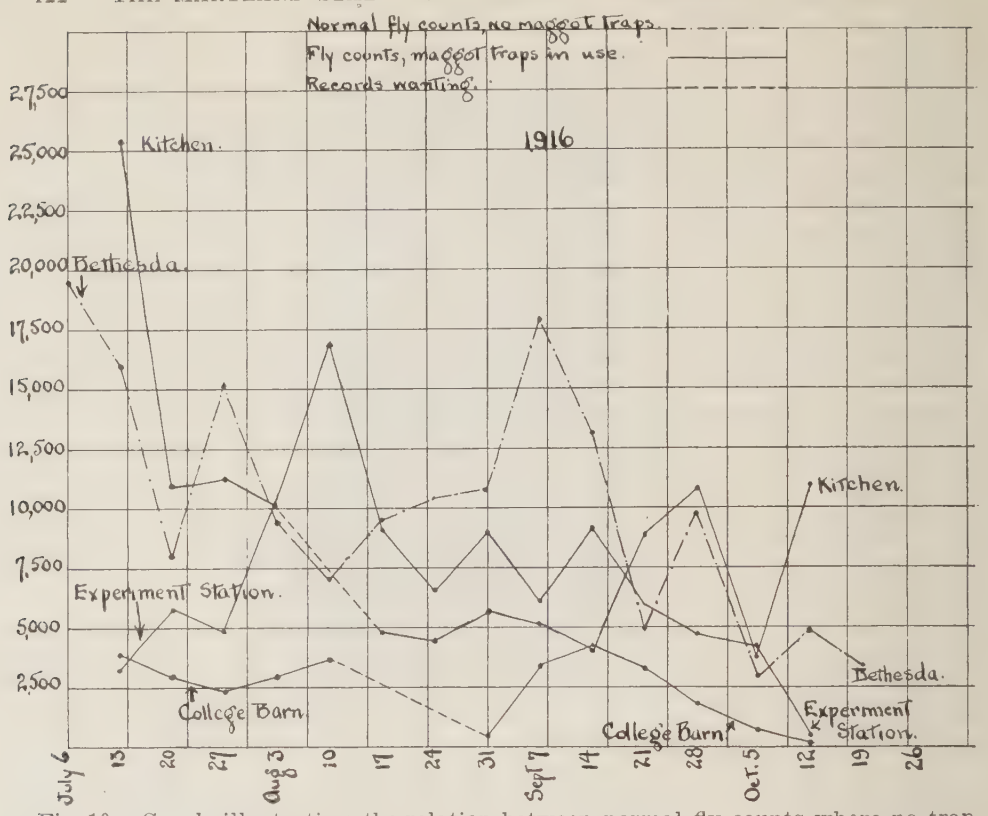


Fig. 10.—Graph illustrating the relation between normal fly counts where no trap was in operation and the counts as affected by the operation of maggot traps, 1916.

Although there is a general decrease in fly prevalence shown by the figures, the decrease is not in proportion to the rate at which maggots were destroyed. The fact may be accounted for in part by the presence of additional breeding places as shown in the first part of this bulletin and by the inherent faults in the method of obtaining the records.

The Seasonal Prevalence of Several Species.

It may be of interest to show in tabular form the count by species as obtained from the traps during the 1916 season. The preponderance of flies is with the species *Musca domestica*.

The few *Stomoxys calcitrans* can be explained by the character of bait used; this species seems equal in numbers during late August and September in the dairy and barns to *M. domestica*, though in the absence of figures, this may be more apparent than real.

Muscina stabulans was quite constant and numerous; *Lucilia* sp., *Calliphort* sp., and *Phormia regina* were evidently attracted by the odor of the dead flies. It is interesting to note the capture of 17 *Chrysomia macellaria* at the garbage cans. This fly has not heretofore been recorded in the State collection.

TABLE IV.

Seasonal Prevalence of Several Species. Combined Records from Three Traps.

Date	Musca domestica	Muscina stabulans	Muscina assimilis	Sarcophagidae	Pollenia rudis	Phormia regina	Lucilia spp.*	Calliphora spp.*	Graphomyia maculata	Ophyra leucostoma	Stomoxys calcitrans	Anthomyidae	Pseudopyrellia cornicina	Tryphetidae sp.	Morellia micans.	Culicidae sp.	Chrysomyia macellaria.	Tachinidae sp.	Spilogaster sp.
7/13/16	32,109	978	392	244	196	234	253	133	51	.....	16	.....	....	.....	....	.....	....	6	....
7/20/16	20,131	591	16	70	540	132	164	3	6	.....	6	.....	....	.....	....	.....	....	6	.....
7/27/16	17,092	385	58	85	760	236	147	28	19	159	160	6	....	.....	....	.....	....	.....	.....
8/ 3/16	24,234	192	11	25	3	136	321	.....	43	65	.....	.....	11	.....	....	.....	....	3	....
8/10/16	20,213	81	3	67	3	38	160	.....	.....	.....	65	12	....	.....	....	.....	....	10	....
8/17/16	13,956	413	57	385	82	51	202	51	.....	51	26	19	13	.....	....	.....	6	6	....
8/24/16	11,161	181	75	257	391	87	208	75	.....	.....	.....	25	....	.....	....	12	....	.....	....
8/31/16	15,229	164	95	377	133	119	156	15	.....	7	9	15	....	.....	7	....	....	.....	4
9/ 5/16	4,216	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	.....	....	.....	....	.....	.....
9/07/16	14,546	173	85	825	103	195	208	20	.....	10	12	44	....	.....	....	.....	....	.....	19
9/12/16	341	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	.....	....	.....	....	.....	.....
9/14/16	17,750	55	6	815	47	188	502	31	6	.....	6	76	....	6	....	.....	....	106	.....
9/21/16	16,155	201	29	639	69	118	96	32	.....	103	27	19	....	.....	32	.....	9	.....	.....
9/28/16	18,372	17	3	13	.....	31	2	1	1	1	.....	.....	....	.....	15	.....	.....	.....	.....
10/ 5/16	4,450	46	.....	7	.....	7	10	.....	.....	3	.....	.....	....	.....	3	.....	2	.....	.....
10/12/16	11,359	10	.....	11	.....	5	9	22	.....	9	.....	.....	....	.....	3	.....	.....	.....	.....
Totals...	241,314	3,494	830	3,820	2,327	1,577	2,438	111	126	408	327	216	24	6	60	12	17	137	23

*Lucilia caesar and L. sericata and Calliphora vomitoria, principally.



Fig. 11.—The maggot traps at the Experiment Station. Cross (x) and white line indicate where the traps have since been cut into two parts. Trap on the left loaded and will lie idle for two weeks while trap on the right is being loaded.

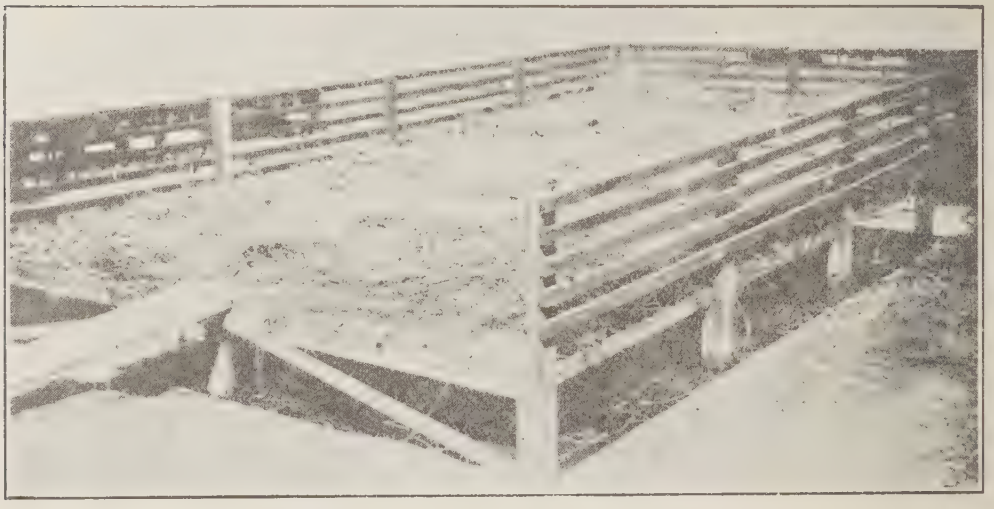


Fig. 12.—Trap prepared for loading.

Modification of the Trap in 1917.

Considerable difficulty was encountered in cleaning the basin of the traps thoroughly and quickly. To obviate this defect the traps were sawed into two sections, reinforced as necessary and provided with the extra legs. This gives two sections to each trap 10 ft. x 10 ft. which can be lifted off the basin at cleaning time by two men. The addition of a short section of ½ in. iron pipe to the end of the hose facilitated the wetting of the manure with the water from the cistern. To further facilitate wetting the manure, water under pressure was piped to the traps in 1917. Fig 11 shows the two traps in operation, with a man watering the manure. It was found necessary, in order to prevent small particles from falling through the slats, to place straw on the platform before the manure was loaded on the trap. Fig. 12 shows one trap prepared in this way.

1.) Hutchison, R. H.

1914. The migratory habit of house-fly larvae as indicating a favorable remedial measure. An account of progress. U. S. Dept. of Agr., Bul. 14, 11 p., Feb. 28.

2.) Hutchison, R. H.

1915. A maggot trap in practical use. An experiment in house-fly control. U. S. Dept. Agr., Bul. 200, 15 p. 3 Pl. 4 Figs. May 4. Record of the first years cooperative experiment with The Maryland Agricultural Experiment Station.

3.) Levy, E. C., and Tuck, W. T.

1913. The maggot trap—A new weapon in our warfare against the typhoid fly. In Amer. Jour. Pub. Health, v. 3, no. 7, p. 657-660, illus., July.

4.) Hewitt, C. G.

1914. Further observations on the breeding habits and control of the house-fly, *Musca domestica*. In Jour. Econ. Ent., v. 7, no. 3, p. 281-293, Figs. 20-21, June.

5.) Deherain, P. P., and Dupont, C.

1900. Sur la composition des gaz confines dans le fumier de ferme. In Ann. Agron., Paris, t. 26, p. 273-294.

Summary.

The migratory habit prior to pupation can be utilized in trapping maggots in manure.

The average percentage of maggot destruction is 95.8% for the seasons 1914, 1915 and 1916.

The reduction in fly prevalence amounted to 76% in 1914. The reduction in 1915 and 1916 are not so marked. The presence of additional fly breeding sources and the difficulty of obtaining accurate results on fly reduction may account for this apparent discrepancy. Modifications of the traps as dictated by experience have evolved a trap that is practical for the farm producing large quantities of manure daily.

The close packing of manure, the watering of the pile and the return of leached materials to the manure tends to conserve the fertilizing value of the manure.

The labor involved is only slightly greater than that required to dump the manure in a pile. The difference is in the time required to water the pile daily and to clean the basin once every two or four weeks, depending upon whether one or two traps are constructed.

The saving in fertilizer and the destruction of a large percentage of the flies particularly on isolated farms will more than repay the cost of construction and operation.

ONLY THE BULLETINS NAMED BELOW ARE AVAILABLE FOR DISTRIBUTION.

These Bulletins are sent free of charge to any address upon application.

Experiment Station Bulletins.

Bulletin No. 58, Aug.,	1898,	The Hessian Fly and Wheat Diseases.
" " 87, Nov.,	1902,	The Periodical Cicada or Seventeen-Year Locust.
" " 91, Feb.,	1904,	Experiments with Nitrogenous Fertilizers.
" " 92, Mar.,	1904,	Notes on Apple Culture.
" " 93, May,	1904,	Pithiness in Celery.
" " 94, July,	1904,	Systems for Keeping Milk and Butter Records.
" " 95, Aug.,	1904,	Character of Milk During the Heat Period.
" " 96, Sept.,	1904,	Sweet Corn.
" " 97, Oct.,	1904,	Relative Profits of Selling Milk, Cream and Butter.
" " 98, Nov.,	1904,	Dairy Feeding Experiments.
" " 100, Mar.,	1905,	The Wild Legumes of Maryland.
" " 101, Apr.,	1905,	Common Injurious and Beneficial Insects in Maryland.
" " 102, May,	1905,	Leucocytes in Milk.
" " 103, June,	1905,	Methods of Tobacco Seed Selection.
" " 119, July.,	1907,	Greenhouse Pests in Maryland.
" " 147, Aug.,	1910,	Wheat—Variety Test, Smut and Scab.
" " 151, Feb.,	1911,	Fertilizers for Asparagus.
" " 154, June,	1911,	Bee Keeping in Maryland.
" " 155, Aug.,	1911,	Maryland Weeds and Other Harmful Plants.
" " 159, Oct.,	1911,	Peach Culture.
" " 161, Nov.,	1911,	Treatment for the San Jose Scale and Terrapin Scale Insects.
" " 162, Dec.,	1911,	The Quality of Seed.
" " 163, Jan.,	1912,	Increasing the Durability of Fence Posts.
" " 164, Feb.,	1912,	Lime-Sulfur as a Summer Spray.
" " 165, Feb.,	1912,	Boys' Corn Growing Contest.
" " 168, July,	1912,	By-Product Feeds.
" " 169, Aug.,	1912,	Cow Testing Associations.
" " 171, Dec.,	1912,	Poultry Notes.
" " 172, Jan.,	1913,	Irish Potato Investigations.
" " 174, Feb.,	1913,	Hog Cholera.
" " 175, Mar.,	1913,	Miscellaneous Insect Pests.
" " 176, April,	1913,	The Peach-Tree Borer.
" " 177, May,	1913,	Open Cow Stable.
" " 178, Oct.,	1913,	Apple Orchard Experiments.
" " 181, Mar.,	1914,	Inexpensive Aids in Producing Sanitary Milk.
" " 183, May,	1914,	Study of Rest Period in Potato Tubers.
" " 187, Nov.,	1914,	Profitable and Unprofitable Cows.
" " 188, Dec.,	1914,	Types and Varieties of Maryland Tobacco.
" " 190, Feb.,	1915,	Tests of Varieties of Corn.
" " 191, Sept.,	1915,	Relation of Catalase and Oxidases to Respiration in Plants.
" " 192, Jan.,	1916,	Internal Actions of Chemicals on Resistance of Tomatoes to Leaf Diseases.
" " 193, Feb.,	1916,	Tests of the Availability of Different Grades of Ground Limestone.
" " 194, Feb.,	1916,	Sudan Grass.
" " 195, Mar.,	1916,	Onions.
" " 196, April,	1916,	Methods in Pear and Apple Breeding.
" " 197, July,	1916,	Clover and Grass Seed Inspected in 1914.
" " 198, Oct.,	1916,	Wheat.
" " 199, Dec.,	1916,	Tests of Stable Manure, Commercial Fertilizers and Crimson Clover for Vegetable Crops.
" " 200, Jan.,	1917,	Winter Oats, Barley, Spelt and Emmer.
" " 201, Feb.,	1917,	Soybeans
" " 202, Feb.,	1917,	Timothy Fertilization and Culture.
" " 203, Mar.,	1917,	Agricultural Seed Inspected in 1915.
" " 204, Mar.,	1917,	Variety Tests of Tomatoes, Potatoes, Cabbage and Other Vegetables.
" " 207, May,	1917,	Plum Growing in Maryland.
" " 208, June,	1917,	Tarsonemus Pallidus Banks, a Pest of Geraniums.
" " 209, Dec.,	1917,	The Oriental Peach Pest (Laspeyresia Molesta Busck), a Dangerous New Fruit Insect of Maryland.
" " 210, Dec.,	1917,	Agricultural Seed Inspected in 1916.
" " 211, Feb.,	1918,	Strawberry Notes.
" " 212, Feb.,	1918,	Physiological Basis for the Preparation of Potatoes for Seed.

Extension Bulletins.

Bulletin No. 1, Sept.,	1916,	Maryland Apple Grading and Packing Law.
" " 2, Oct.,	1916,	Relation of Lime to Agriculture.
" " 3, Feb.,	1917,	The Garden.
" " 4, May,	1917,	Federal Farm Loan Act and the Farmer.
" " 5, May,	1917,	Garden Record Book.
" " 6, June,	1917,	What Maryland's Farmer Boys and Girls Can Do to Help the Nation this Summer.
" " 7, Aug.,	1917,	The Hessian Fly.
" " 8, Dec.,	1917,	Insects and Rodents Injurious to Stored Products.
" " 9, Dec.,	1917,	Electricity on the Farm.

THE CONTROL OF HOUSE FLIES BY THE MAGGOT TRAP

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BUREAU OF ENTOMOLOGY
★ OCT 7-1918 ★
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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

Lecture 17, Sept. 18, 1918.

A SYNOPSIS OF THE COOTIE PROBLEM.

W. D. Pierce.

Since the presentation of lectures 3,4,5 and 6 on the louse or cootie problem there has been a great amount of experimentation and furthermore some very important publications have been issued on the subject. Dr. Nuttall has completed his comprehensive series of publications on the habits and control of the lice. In Parasitology, volume 9, No. 4, he gives some biological studies of Pediculus, in volume 10, No. 1 he presents a comprehensive bibliography, covers the disease transmission and summarize all that has been done on the biology of Pediculus. In No. 2 he discusses Phthirus pubis in more detail than it has ever been treated. In No. 4 he presents a very comprehensive summary of control measures.

Professor William Moore of Minnesota has added much within the year to the problem. In the Journal of Laboratory and Chemical Medicine, volume 3, No. 9, 1918 he summarizes many experiments with sachets, louse powders, impregnation of underwear, and fumigation. In the Journal of American Medical Association, vol. 71, No. 7, 1918, he summarizes his experiments in the impregnation of underwear. He has likewise submitted reports on the laundry processes, which have been supplemented and verified by Lieutenant Moscowitz and the writer. Mr. R.H.Hutchison has accumulated a great deal of valuable information soon to be reported.

The complete report of the British Committee on trench fever has appeared in the same Journal, volume 71, pp. 21-26,110-113, 188-193. The last mentioned pages cites the proofs of louse transmission.

We are now nearing the season of the year when the louse problem will again become critical in Europe and unless great caution is observed, in some parts of America. It is therefore due the members of the class that they be presented with a concise synopsis of the problem as it now stands. This is reduced to the simplest terms possible and only includes under control measures those which appear most practicable.

Species of human lice.

1. Head louse - Pediculus humanus humanus (capitis).

2. Body or clothing louse - Cootie - Pediculus humanus corporis (vestimenti).

3. Pubic or crab louse - Phthirus pubis (inguinalis)

Why we fear the lice (See Parasitology X, No. 1).

Diseases are caused by bites of lice, called pediculosis and phthiriasis.

Skin diseases designated as

a. Urticaria.

b. Morbus errorum or vagabond's disease.

c. Melanodermia (skin pigmentation).

d. Prurigo senilis.

e. Eczema.

f. Porrigo

g. Pustular dermatitis.

Diseases are carried by lice.

1. Typhus fever caused by Bacillus typhi-exanthematici Plotz was proven transmissible by lice by Nicolle, Comte, and Conseil in 1909 and many proofs have since been added.

2. Trench fever, caused by an unknown organism (possibly the Spirochaeta gallica Convy and Dujarric de la Riviere), was proven transmissible by lice by Davies and Weldon in (1917) and the definite manner of the transmission was first proven by the British Committee headed by W. Byam in 1918 and almost immediately verified by the American Red Cross Committee,

3. Relapsing fevers.

a. The Asiatic form caused by Spiroschaudinnia carteri Mackie was proven transmissible by lice by Mackie in 1907.

b. The North African form caused by Spiroschaudinnia berbera Sergent and Foley was proven transmissible by lice by Sergent and Foley in (1908).

c. The European form caused by Spiroschaudinnia recurrentis Lebert was proven transmissible by rat live by Manteufel (1907) and since then various writers have shown that human live can carry it.

d. The tropical African form caused by Spiroschaudinnia duttoni Novy and Knapp was shown to be occasionally transmitted from rat to rat by rat lice by Neumann (1909)

e. Manchurian relapsing fever was claimed by Toyada (1917) to be transmitted by lice.

4. Volhynian fever or five day fever, said by Da Rocha Lima to be caused by Rickettsia pediculi, Da Rocha Lima was shown by Töpfer (1916) and Jungmann and Kuczynski (1917) to be transmitted by lice.

5. Plague caused by Bacillus pestis has been experimentally transmitted by inoculation of crushed infected lice by Swellengrebel and Ottens (1914) and De Raadt (1916).

6. Typhoid fever caused by Bacillus typhosus Eberth was recovered by Abe (1907) from lice fed on typhoid patients.

7. Leprosy caused by Bacillus leprae Hanoon was recovered by Mc Coy and Clegg (1912) from lice collected on lepers.

8. Cerebrospinal meningitis caused by Diplococcus intracellularis meningitidis Weichselbaum was recovered from lice collected on patients by Pizzini (1917) and an epidemic was believed by him to have been spread by lice.

9. Phlyctenular conjunctivitis and keratitis are believed to be spread by head lice by De Font Reaulz (1912) and Hudson (1914)

10. Impetigo contagiosa was proven transmissible by head lice by Dewevere (1892).

11. Tropical impetigo caused by Diplococcus pemphigi contagiosi Manson is claimed by MacGregor (1917) to be transmitted by lice, but his authority is not cited.

12. Favus caused by Achorion schoenleini Lebert is claimed by Aubert (1879) to be spread by lice.

13. Pityriasis caused by Malassezia spp. is claimed by Aubert (1879) to be spread by lice.

How lice cause or carry disease.

1. They cause disease by their irritating bites.

2. They carry diseases by sucking up disease organisms from the blood of men and passing these organisms through their bodies and out in their excreta. These are inoculated into the flesh by --

   a. Scratching into the skin the excreta, even when dried.

   b. Scratching into the skin fragments of the louse body containing disease germs.

   c. Biting of the louse through a film of excreta.

How the lice live (See Parasitology X No. 1).

Their habitats.

1. The head louse lives on the human head especially at the occiput and sides of head, above and behind the ears among the hairs, and more rarely on other hairy pates of the body.

2. The body louse lives on the human body, frequenting the clothes principally, but is rarely found in the hair.

3. The pubic louse lives in the hairs of the pubic region. Less

frequently in the axillae and on the head, in the beard and on the eyelashes.

Egg state - nits.

1. Head lice deposit nits on the hairs of the head and body, rarely on cloth and hats.

2. Body lice deposit nits on threads of clothing, especially in seams and under pockets, rarely on hairs of body.

3. Pubic lice deposit nits on pubic hairs, or hairs of other parts of body, rarely on clothing.

The egg stage varies according to climate from 4 to 16 days, under normal conditions and up to 35 days in cold weather.

Eggs are laid at the rate of 9 to 15 per day for 20 or 30 days with a possible total of at least 300.

The most favorable temperature for the egg is 86°F. (30°C.).

The high temperature of 140°F (60°C.) is generally regarded as fatal to all eggs, although a sufficiently long exposure at 112° F. is fatal.

Nymphal State.

There are three larval or mymphal stages.

Developmental period.

Development varies with climate but the entire cycle may be as short as 15 days.

Length of life.

The longest record of life is 46 days for an adult.

The longest record of life without food is 10 days at 41°F. (5o C.).

Sources of infection.

Reservoirs of louse breeding in America.

1. Lumber camps, especially in coal countries (Michigan, Wisconsin, etc.

2. Jails, poor houses, lodging houses, etc.

3. Mining communities.

4. Construction camps.

5. Negro communities.

6. Mexican and Indian populations.

7. Ghettos,

8. Tramps and Vagabonds.

Reservoirs of louse breeding in Europe and other parts of world.

1. Trenches, and Army concentration points.

2. Refugees and prisoner concentration zones.

3. Jewish concentration zones of Eastern Europe.

4. Crowded communities of poor people.

5. Mohammedans, and other religious sects opposed to killing insects.

6. Ignorant degraded people everywhere.

Control Measures - (properly called lousing, not delousing) (See Parasitology X, No. 4).

Education as to the dangers and means of control os important.

1. Press statements.

2. Moving pictures.

3. Bulletins.

4. Lectures.

5. Personal demonstrations.

Personal prophylaxis where possible.

1. Daily or weekly bath according to convenience.

2. Daily personal inspection of clothing, especially along seams.

3. Weekly official inspection.

Control of the lice on the body.

1. Head louse.

a. Daily combing, brushing and periodic washing.

b. Clipping of hair. It is well to keep childrens hair short.

c. Wash head with equal parts kerosene and acetic acid one half hour, keeping head covered with towel. Use comb with fine teeth.

Wash head with warm water and soap containing kerosene. (Nuttall).

d. Have patient lie down with head over edge of bed above a basin resting on a chair, wash head and hair in 2 1/2 % solution of carbolic acid for 10 minutes, wring out moderately wrap head in a towel for 1 hour. Then wash the hair and merely let the carbolic dry. To remove the nits apply 25% acetic acid and use fine comb.

e. Hair oil or pomade as used in certain classes and races is efficient.

f. Anoint head with a mixture of equal parts of kerosene and olive oil, wrap the head in a towel and sleep in it. Apply vinegar and remove nits with fine comb, then wash out with warm water and soap. This may be repeated for 2 or 3 nights if necessary.

Bathing facilities available

a. Thorough bathing in warm water with liberal use of soap.

b. Where many men are being bathed it may be feasible to spray them preceding bath with:

1. Gasoline

2. Liquid kerosene or gasoline soap emulsion made as follows:

Boil one part soap chips in four parts water then add two parts kerosene oil or four parts gasoline. This jellies when cold, and one part of this jelly added to four parts of warm water, makes a good liquid soap at very small cost.

c. Soaps may be made up as follows:

1. 5 % carbolic acid and soft soap, equal parts.

2. 5 % Cresol and soft soap, equal parts.

3. 2 % Lysol and soft soap, equal parts.

d. For wounded men after shower bath, soap down with a brush using an emulsion of petroleum 1 pt, soft soap 2 pts, lysol solution 1 pt. Afterwards apply 3 % cresol ointment to the hairy parts, This is recommended by Adler-Herrmark.

Herrmark

Water in small quantities only available.

A. Sponge off body using one of the above mentioned soaps.

b. Sponge with 2% crude carbolic acid solution.

c. Anoint the body with an unguent.

1. Ordinary grease.
2. Vermi jelly (Maxwell-Lefroy) made up of:

Texas fuel oil, gr. 0.86, 250 to 350°C.	50 Pts
Crude vaseline	20 "
soap soap	30 "

Water in small quantities only available.

a Sponge off body using above mentioned kerosene or gasoline emulsion soap.

No water available.

A Dust insecticidal powders in clothing.

aa. N.C.L. in common use at front is made of

naphthalene	96%
Creosote	2%
iodoform	2%

bb. Naphthalene alone is commonly used, but its continuous use may injure the eyes.

cc. The most effective powder is made of

Creosote	1 cc.
Sulphur	1/2 gr.
Talc	20 " (Moore)

dd. William Moore has listed numerous other effective powders (Journ. Lab. Clin. Med. III No. 5).

b. Hang sachets next to body.

aa. Nuttall and also Moore reported unfavorably for sachets in general because of their short period of effectiveness.

bb. Following formula has given results and prevented breeding when placed on pieces of cloth where lice congregate:

Oil of lemon grass	300 cc.
Oil of pennyroyal	300 cc.
Oil of eucalyptus	300 cc.
Powdered naphthalene	100 gr.

Renew from time to time.

cc. The following substances exert repellent action on lice: oils of anise, cloves, eucalyptus, naphthalene, carbolic acid.

c. Wear cheesecloth suit impregnated with saturated solution of sulphur in creosote on outside underwear. (Moore).

d. Impregnate underwear and other garments with vermicides.

aa. Moore has tested many substances and finds that the cost of application is too high for the results obtained and none are effective longer than a week. (Journ. Am. Med. Ass'n., vol. 71, No. 7. In a subsequent report Moore and Hirschfelder show that there is more hope of success from cresol compounds than from any thing else). naphthalene and

3. Crab louse

a. Bathe using an insecticidal soap .
b. The cutting or shaving of the pubic hairs is to be avoided because of irritation when marching.
c. Anoint with mercurial ointment (blue ointment).
d. Anoint with yellow oxide of mercury ointment.
e. Do not use N.C.I. or other powders in the pubic regions.

Control of the lice on clothing.

1. Laundry control.

a. The ordinary camp laundry processes may be adapted to meet all requirements (Pierce and Moscowitz). Following process is satisfactory for cotton and woolen underwear and uniforms.

1. Wash for 20 minutes at 131°F. (55°C.) with a heavy suds, the machine must not be over half full.

2. Rinse three times for 3 minutes each in clear water at 101°F. (55°C.), using if desired an insecticidal soap in the first rinse.

3. Extract water in centrifugal extractor, 15 minutes.

4. Dry in dry tumbler (temp. 150° to 200o F.) 15 minutes.

5. Mangle underwear.

6. Press uniforms.

b. For cotton underwear the following common laundry wash formula is effective (Moore).

1. Wash 5 min. at 100° F.
2. Wash in neutral soap 15 min. at 180° F.
3. Wash in neutral soap 15 min. at 180° F.
4. Wash in soda bath 10 min. at 130o F.
5. Rinse 5 min. at 130°F.
6, Extract.
7. Dry in tumbler 20 min. at 190° F.
8.. Mangle.

c. For cotton khaki cloth (Moore)

1. Wash 5 min. at 100°F.
2. Wash in neutral soap at least 30 min. at 125°F.
3. Rinse 5 min. at 125°F.
4. Extract.
5. Dry in tumbler 10 min. at 180°F.
6. Iron.

2. Permanent delousing installations.

a. Permanent laundries (see above).
b. Mobile laundry units (same processes as permanent laundry but cutting out the mangling or ironing.
c. Sanitary corps delousing units in the form of a building, tents, trains, mobile tractor or horse drawn units, consisting essentially of:
   1. Check room for materials not needing treatment.
   2. Undressing room.
   3. Sterilizer or delousing apparatus.
   4. Barber shop.
   5. Toilets.
   6. Baths.
   7. Drying room.
   8. Towel and soap supply.
   9. Dressing room.
   10. Pressing room.
   11. Heating plant.

d. Heat delousing apparatus (See Parasitology X, No. 4.)

1.
   1. Stagnant hot air has less effect than fresh hot air.
   2. The essential temperature for louse control is 131°F. (55°C.) for 30 minutes, or 140o F. (60°C. for 15 minutes.
   3. In order to control the temperature Nuttall advises use of pure chemical substances with known melting point and mixing with some available dry aniline dye. The substance is colorless until melted when it takes the color of the dye. This may be placed in a small glass tube sealed at both ends and placed where it can be seen from the outside. The following substances are suggested;

100°C. ---Mallic acid.
82o C. ---Glucose.
7[illegible]°C. ---Urea.
70°C. ---Steric acid.
63°C. ---Cumidin, 1,2,4,5, or paraiodonaline.
60°C ---Margaric acid, or dinitrotoluol, 1,2,4.
55-56°C.---Asotoluol, or dimethydrochinon.
54°C. ---Benzyladine aniline, or myristic acid.

4. Garments must be hung loosely.
5. Some device should be used to circulate the air in order to insure the necessary heat for the necessary time.
6. A traveling hanger in a tubular oven might be of value in assuring removal of garments in rotation.
7. The heat chamber may be a:
    a. Portable box as a fireless cooker, etc.
    b. Room heated by steam pipes or hot air.
    c. Sod hut.
    d. Steel autoclave.
    e. improvised oven.

8. The laundry dry tumbler which attains very high heat must not be used on dry garments as it disintegrates the fivres of woolens and causes shrinkage. (Moscowitz).

e. Steam disinfection apparatus.

1. Steam disinfection if carried out improperly is destructive to woolens (see Nuttall).
2. Steam under pressure in autoclaves, vacuum cylinders or rooms. Staniford (Journ. Amer. Med. Assoc., vol. 71, No. 10. pp. 823-824) recommend the following proceedure:
    a. Woolen blankets or uniforms on hangers or loosely on traps in the sterilizer.
    b. Introduce 60 lbs. steam into outer jacket to prevent subsequent condensation within sterilizing chamber.
    c. Create 15 or 20 inch vacuum to facilitate penetration of the clothing by steam.
    d. Sterilize with steam:
        1. No pounds (atmospheric pressure) for one hour.
        2. 12 pounds steam for 10 minutes.
    e. Produce 15 to 20 inch vacuum to facilitate drying.
    f. Open the door of the sterilizer about four inches for 10 minutes to allow gradual cooling of the contents of the sterilizer.
    g. Steam under pressure will disintegrate woolens if the exposure is over 10 minutes.
    h. The bacterial sterilization requires the preliminary vacuum and loose packing
    i. Nuttall (Parasitology vol. 10, No. 4) has long discussion.

3. Live or current steam fumigation as used by Stammers (Wm. Hunter in Brit. Med. Journ., Aug. 24,

a. Railroad train. Steam generated by engine. Cars filled with steam through perforated tubes. Steam has exit through cracks about doors; reaches about 105°C at about normal pressure. Clothing placed in bags or shelves may almost fill car. Sterilization lasts one hour. Shake clothes out immediately on removal. Hunter claims that a double van(railroad) in egypt and Serbia had a capacity of 500 kits with 1000 blankets and 500 overcoats every two hours. This is the largest scope plan available outside of fumigation.

b. Stammer's barrel disinfector (Serbian barrel) (See Hunter l.c.). Old wine barrel with five or six round holes in bottom, placed on circular boiler of cast iron or galvanized iron. Fill space between boiler and barrel with a narrow sausage ring, filled with sand, to prevent escape of steam except through barrel. Build fire in a pit beneath boiler. Place cross bars in bottom to keep clothesfrom holes. When the steam is escaping too hot for the hand the time required for delousing is onehhour. Cover barrel with heavy wooden lid. Each company while on campaign duty should be provided with two or more of these barrels.

c. Galvanized iron bin with water in bottom and a grid to keep clothes out of water, placed over fire. (See Hunter, l.c.). Anordinary garbage can as used in the army would do for a small quantity of garments. Same principle as the barrel.

d. Exposure to live steam 20 minutes in any kind of chamber is sufficient. Care must be taken not to overload.

e. Laundry wash machines are available for steam disinfection.

f. Dry cleaning apparatus.

1. In permanent and semipermanent institutions where practicable the Reclamation Service will clean all uniforms and overcoats turned back by dry cleaning processes rather than by laundry or steam sterilization. This process does away absolutely with all danger of injury to the woolens which might result from carelessly letting temperatures run too high.
2. Soak clothes in gasoline 20 minutes in washing machine. Exposure of 10 minutes to gasoline kills nits.
3. Press the suits and they are ready for repair or reissue
4. The gasoline is almost entirely recovered for future use.

g. Fumigation.

When fumigation chambers are available and the clothing is needed for immediate wear this is one of the quickest means of delousing.

1. The fumigarion chamber may be:

a. A room with cracks tightly sealed and vestibuled doors. A sign of warning should be posted and the door kept locked during fumigations. Only persons understanding fumigation should be permitted around

and they should wear gas masks.

b. A chest or box is sufficient for carbon bisulphide or chlorpicrin.

c. A protable unit, such as an automobile with an air tight chamber, and with hangers or shelves. Gas generator behind chauffeur's seat.

d. Vacuum chamber as in steam sterilization. The same cylinder may be made availabel for either steam or gas.

2. The fumigation may be by:

a. Formaldehyde in vacuum for 45 minutes using 12% formaldehyde and water vapor.

b. Cyanide in vacuum.

1. For chests, trunks and tightly packed garments 25 inch vacuum, 30 minutes exposure, 4 ounces sodium cyanide per 100 cubic feet (Lamson).

2. For loosely hung clothes 20 inch vacuum, 30 minutes exposure, 3 ounces cyanide per 100 cubic feet (Lamson).

3. The hydrocyanic acid gas (DANGEROUS) is generated in an air tight generator, which is connected by a pipe with the fumigation chamber by combining 2 1/2 parts of sodium cyanide solution (made by dissolving 4 lbs. of sodium cyanide, guaranteed to contain 51% cyanogen, in 1 gallon of water), 1 part of commercial sulphuric acid (184 sp. gr., or 66° Baume) and 1 part of water.
Create 25 inch vacuum. Generate gas 5 minutes in generator. Wash over into fumigation chamber. Break vacuum so as to fumigate in normal atmospheric pressure 25 minutes. Remove gas by producing 25 inch vacuum. Return to normal pressure. Open door slightly and run vacuum pump a few minutes. Remove material. (Sasscer) (See Fed. Hort. Bd., Service and Reg. Announcement 21, Dec. 4, 1915)
ONLY EXPERIENCED MEN CAN BE PERMITTED TO HAND* LE.

c. Chlorpicrin in galvanized cans using 4 cc. to 1 cu. ft. for 30 minutes and apolying a little heat. DANGEROUS GAS. (Moore).

d. Carbon bisulphide is an inflammable but efficient fumigant but too slow for most army purposes. Place garments in any kind of tight box and pour in the liquid at the rate of 1 lb. to 1000 cubic feet of space. Leave for 24 hours.

3. Storage.

a. Storage of infested garments, dry at 54°-68°F. (12-20°C), for two or three weeks is effective.

b. Bedding and clothing may be put away in naphthalene crystals or moth balls.

4. Impromptu delousing arrangements.

a. Serbian barrels (as described above), kettles, any device for steaming garments (see Parasitology, vol. 10, No. 4,)
b. Heating boxes require 131°F. for 30 minutes.
   1. Fireless cookers with heated bricks.
   2. Electric heated boxes.
   3. Metal ovens.
   4. Brick or clay ovens.
c. Boil clothes in water five minutes.
d. Soak woolens in hot water at 131°C. ten minutes.
e. Soak clothes in insecticides.
   1. Immerse in petrol (gasoline) or benzine bath.
   2. Wash with Maxwell-Lefroy's soap.

Crude mineral oil sp. gran. o,9 -	56 grams
Soft soap	30 "
water	6 grams.

3. Wash for 15 minutes in 10 percent solution of on of the followin soaps; then wring out and dry:

A.

Naphtha soap	65 percent
cresol	35 "

b.

Naphtha soap	65 "
100 % crude carbolic acid	35 "

c.

Naphtha soap	65 "
Xylol	35 "

d. To obtain a ten percent solution dissolve 3 pounds in a bucket of water. The odor will be retained a long time and keep lice away.

4. Soak for 10 minutes in 2 percent solution of cresol, wring out and dry. A quart of cresol in 12 1/2 gallons of water is enough to kill the lice in the body linen of 62 men, each garment being wrung out to recover as much as possible of the linen.

f. Brushing and beating and handpicking if done thoroughly and regularly is often effective.

g. Hot ironing if done well is effective.

Control of lice in hats, shoes , accoutrements and furs.

1. Treatment of hats.

a. Felt hats can not be steamed unless the bands are removed The army renovation process of repairing hats will kill all nits.
b. Trench hats can be washed in the laundry in the same manner as the woolen uniforms.
c. Fumigation by cyanide as described for clothing.
d. Sponge with 10 percent carbolic acid solution.

2. Treatment of shoes and leather.

a. Hot air at 140°F. for 15 minutes, or 131°F. for 30 minutes.
b. Laundry in cresol bath according to process worked out by Shoe Repair Section of Conservation and Reclamation.
c/ Fumigation by cyanide as described for clothing.
d. Treatment with trichlorethylene ($C_2H Cl_3$) (boiling point 88°C. or 191°F. sp. gr. 1, 47).

3. Treatment of accoutrements.

a. Fumigation by cyanide as described for clothing.
b. Treatment with trichlorethylene.
c. Fumigation with chlorpicrin in tight receptacle, 4 cc. to 1 cu. ft. for 30 minutes, with a little heat.

4. Treatment of furs.

a. Hot air at 140°F. for 15 minutes, or 131°F. for 30 minutes, if packed loosely.

Control of lice in quatters.

1. Cleanse beds with gasoline or kerosene. Permit no fires.
2. Send bedding and linens to laundry.
3. Fumigate mattresses and pillows in fumigation chamber with cyanide as described for clothing.
4. Fumigate entire building--tightly close all openings in building and seal up cracks with paper, unless the insects are in the double walls. Then seal cracks on outside. It may be necessary if building is too loosely constructed to increase dosages or make a tarpaulin to cover entire structure. Such measures should only be taken incase the normal fumigation was unsuccessful. Any of the following methods is practicable. Entomologists prefer cyanide but many army officials prefer sulphur.

   a. Sulphur(remove all metal)

      1. Clayton gas, generated by burning common roll brimstone in an oven or generator outside of the building. A very high heat is generated. The gas is passed over two baffle plates before reaching the outlet pipe which is cooled by water circulating in pipes around it in in an ordinary steam boiler tank. The gas then is passed into the building to be fumigated. This gas is a mixture of sulphur dioxide and sulphur trioxide. As the gas is heavier than air there must be circulation through the roof of a building or hatch of a ship until the gas begins to come out in quantity.

      2. Burn sulphur candles, being careful to isolate them by sufficient metal from all woodwork, at rate of 4 pounds per 1000 cubic feet, for 6 hours.

      3. Sulphur fumigation is described in Public Health Bull. 34, 1910 with special reference to ships, and in Entomology bull. 60, 1906 with reference to general fumigation.

   b. Cyanide.

      1. Sodium cyanide only is now available. Generate in earthen jars placing in the jar 1 1/2 oz. sulphuric acid and 2 oz water to every ounce of cyanide to be used. Arrange the cyanide in a package suspended over the jar so that it can be released by the operator at a distance by pulling or releasing a cord. The gas is generated very rapidly and is exceedingly dangerous. Use 10 ounces of cyanide for each 1000 cu.

ft. and expose for 2 hours. This will kill all other insects present.

2.2/ Potassium cyanide should be used at the rate of 1 oz cyanide to 1 oz. sulphuric acid, and 3 oz. of water.

d. The most practical method for fumigation of any kind would be a mobile motor fumigator with hose attachments capable of treating any building, tent or car. If this unit had a tight fumigation room, garments could be hung therein and practically fumigated. The installation should be equipped with generators for cyanide, formaldehyde, or sulphur fumigation, and be placed in charge of practical fumigation experts.

Control of lice in hospitals.

1. Moisten floors and walls with cresol or phenol.
2. If possible patients should be washed before placing on clean beds.
3. Attendants should wear clothes with few openings.
4. Band legs of beds with corrosive sublimate to prevent infection from other beds.
5. Cleanse each bed before putting a new patient on it.
6. Obtain free ventilation with fresh air.
7. Have bedding disinfected for each case.

Control of lice in treaches and dugouts.

1. Spray walls with cresol or phenol solutions.
2. Scrape walls, sprinkle the dust with corrosive sublimate and remove.
3. When possible provide in dugouts a disinfecting kettle or box, or barrel in which clothes can be treated with an insecticide as described under clothing.
4. When possible remove bedding and other comforts in which lice might lurk, to rear, for disinfection.

Louse proof garments for medical attendants, etc.

1. Smooth clothing, preferably rubber or oiled silk.
2. Long coats, extending below the knee and buttoning behind.
3. Sleeves narrow to the wrists.
4. Rubber gloves drawn up to overlap edges of sleeves.
5. Collars to button close around the neck.
6. Head covered by a hood.
7. Rubber or smooth leather top boots.
8. A one piece suit fastened at shoulders by buttons with trousers closed at ends like stockings. Wear sandals over the feet. Rubber cap.
9. Smooth capes are sometimes of value.
10. Smooth silk underwear may afford a measure of protection.

PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY

Lecture 18. OF DISEASE, HYGIENE AND SANITATION.

Sept. 30, 1918. MOSQUITO CONTROL.

Probably more money and more concentrated effort has been devoted to mosquito control throughout the world than to the control of any other disease bearing insects. We may discuss the essential elements of mosquito control topically.

PREVENTION OF MOSQUITO BREEDING.

By far the most important measures to be taken are those which prevent the breeding of mosquitoes. In this class of measures we therefore have to deal in some manner with water. In general mosquito control is sought it is not essential to ascertain the species breeding, but when large communities or armies are to be protected against disease bearing mosquitoes, time may not permit of general mosquito control but may necessitate particular attention to the haunts of the disease bearers.

SCOUTING.

The preliminary measures to be taken therefore are the organization and training of scouting parties designated primarily to search out the breeding haunts of these species and report them to the details or squads designated for control work. The scouts must be trained entomologists skilled in the knowledge of mosquito haunts. They must examine the water in all receptacles in and around buildings, and in discarded vessels. They must seek out all puddles, hoof prints wagon ruts, tree holes, ditches and streams and carefully examine these. A chart should be kept showing the location of all water and this can be marked in various ways to indicate the species present. Colored pin markers on a wall chart are very serviceable. A field chart would have to be marked otherwise.

Leveling and Filling Water Holes.

Details of men may be designated to look after the leveling of ground where water is apt to gather, and remain and to fill up small puddles, pools, hoof marks ruts etc, which serve no useful purpose and where drainage is inadvisable. Holes in trees should be filled up with cement. Stumps which hold water should be grubbed out and the stump holes filled. In rocky streams pot holes in the rocks often breed many mosquitoes. If possible the rock should be grooved, or removed, or the holes may be filled with cement.

Ditching and Clearing Streams and Swamps.

Other details may be designated to clear stream beds and drain low lands. Spring lands, bogs and swamps furnish an abundance of mosquitoes and are the first places to receive the attention of the ditching squads. Ditches must be constructed to carry off standing water. These should be laid out by an engineer

The ditches must have straight banks and even bed and must be kept free of vegetation. Sometimes it is necessary to spray the vegetation along the ditches with oil and burn. All burrow pits and puddles caused by grading roads and railways should be connected up by a ditching system or filled. Flowing streams usually have trees along their sides, Under such trees water is often trapped to form a quiet undisturbed place for mosquito larvae. Trees must not grow on the edge of the bank. Tree roots must be removed from the stream. Any kind of vegetation growing in the bed of a stream favors mosquito breeding as it affords some protection against natural enemies, and prevents adequate artificial control. The stream bed must be clear of vegetation. The banks must be straightened and without overhanging ledges. There should be no obstruction to the free flow of the stream. If it meanders, a new and straight course ought to be constructed and the old course filled. Springs which furnish good water should be boxed and protected. Le Prince and Orenstein very ably describe in their book, the methods of clearing streams and propagation areas in jungles in the tropics.

Clearing of weed filled bays and lakes.

Large bodies of water in which dense growths of grass and weeds occur furnish great problems in many camps and in tropical countries especially where feasible it is often desirable to furnish the mosquito squad with two motor boats and submarine saws or other implements for cutting and removing vegetation. If this cut vegetation remains it agravates the situation. Large lily leaves which when alive furnish no place for breeding, will often when dry form cups for water, in which mosquitoes breed prolifically.

Drainage.

The construction of drainage systems should preferably be done by a sanitary engineer who understands the mosquito phase of the problems. The main ditches should be constructed first and later the laterals added. Sometimes where weed growth is rapid it is desirable to have a double parallel series of ditches, one only operating at a time, during heavy rains, with the idea that the idle ditch can be cleaned and shaped up. It is essential that the floor level of the ditch afford no opportunities for puddles to form after the greater part of the water has passed off. In permanent ditching it is sometimes feasible and advisable to line the ditch with concrete or at least to line the bottom. Weep holes should be made at sufficient intervals to carry into the drain, water which gathers on the outside of it. Branch ditches should enter the main ditch at an acute angle or on a curve. At the junction of ditches there should be a splash wall to confine the water within the ditch. Pot holes formed in dirt ditches should be filled up after rains with gravel or stone and tamped hard (See Le Prince and Orenstein, pp. 137-144).

In certain soils where seepage water out-crops abundantly on hillsides it is sometimes practicable to install an intercepting tile drainage system. The tiles are laid at right angles to the flow of the seepage at the highest seepage water level, with a space of one eighth to a quarter inch between joints. The grade of the trench bottom must be true. Tiles must not be located on soft mud where they may sink. The outlet should be well above the ground surface. (see Le Prince and Orenstein, pp. 130-136).

When ditches become matted with algae and other matter and contain mosquito larvae, in some localities it is possible to construct water gates to permit temporaty impounding of water, which will enable the ditch squads to thoroughly flush the ditch below the gate and remove all mosquito larvae and algae.

Larvacides.

The ditching , draining and clearing of water ways ensures a regualr flow and carries off all surplus water and reduces but does not prevent mosquito breeding. It is necessary to use some additional means of control and for this purpose various larvacides have been applied, but principally kerosene, and crude oils of paraffin and of asphaltum base as well as creosote oils.

The question of the effect of oils on mosquito larvae is most thoroughly discussed by Freeborn and Atsatt who find that the toxicity of the petroleum oils as mosquito larvicides increases with an increase in volatility, the more volatile oils producing the more marked lethal effects. The volatile constituents of the oils contain the principles that produce the primary lethal effects. The lethal effects are produced by the penetration of the tracheal tissue by the volatile gases of the oils. In the heaviest and least volatile oils, having a boiling point greater than 250°C., this action may be supplemented or apparently secondary to the effect of actual contact of the oil with the body tissue or perhaps to mechanical means such as suffocation or plugging of the tracheae. They found that oils which killed very quickly did so by means of the volatile gases, whereas in case of oils with slow effectiveness the mechanical suffocation may be the cause of death.

This paper is so recent that it has not been possible to obtain a mass of evidence on the practical effectiveness of different grades of oils used as larvicides. Kerosene and crude oil are the oils most commonly used in general practise. Le Prince and Orenstein prefer crude oil to kerosene because of the film made by kerosene, its greater expense, inflammability,and liability to be wasted because of its transparency.

Thes/authors have ste down a number of requirements for a good larvicide.

1. It shall have a high toxic power, so that a small quantity may suffice for a large volume of water.

2. It shall kill rapidly in order that subsequent dilution and weakening by rain have as light effect as possible.

3. It must be uniform in its toxic power and capable of standardization.

4. It should mix freely with brackish and alkaline waters.

5. It must be harmless to man and domestic animals, when in the dilution necessary for larvacidal action.

6. It shall not be susceptible to rapid deterioration.

7. It must be inexpensive.

They did not find any substance which fulfilled all these conditions but found a soap , now known as the Panama larvacide to meet most of their requirement

This was made of the following ingredients:

Resin	150 to 200 pounds
Soda	30 "
Carbolic acid (sp.gr.0,97)	150 gallons

This makes a liquid soap which freely emulsifies with fresh water. The carbolic acid must have at least 15 % of phenols and no greater specific gravity than 0.97.

This larvicide is manufactured as follows: Heat the carbolic acid in a steel tank with steam coil. When steaming hot add the resin and continuously stir the mixture by means of a paddle agitator until complete solution is effected. Dissolve the caustic soda in 6 gallons of water and add to the mixture. Heat and stir for five minutes. Draw a sample and pour into water. If it emulsifies the process is complete, and the product may be put into shipping drums which must be tightly closed.

Oiling.

There are many ways of applying the oil. The commonest method is by knapsack sprayer, or where the ditch is along a road by horse drawn tanks fitted with a spraying bar. For slow moving water, and stagnant water, as well as the treatment of ruts, puddles, hoof prints and so forth, these methods are satisfactory.

For moving water there are many devices for maintaining a regular dripping of oil from a suspended vessel upon the surface of the water. Such devices can easily be rigged up by any practical man.

The war has brought about however some new and even more efficient methods of oiling which have been developed along many angles by Dr. Mann the Post Surgeon and Lieut. Ebert of the Marine Corps at Quantico, Va., with the assistance of Pharmacists Mate Duncan. They have found that sawdust impregnated with crude oil will hold it for a long time and will slowly give it up to the water. They therefore place the sawdust impregnated with oil in a box and sink it in a flowing stream; or they throw a few grains of dawdust in a hoof print, or a handful on a puddle; or they fix a floating boom to hold back of it a quantity of sawdust and give off a constant film. For each condition a slight modification of the application and they obtain an excellent and lasting film, not destroyed by rains.

Dr. Ebert's automatic oiler is a cylinder sunk beneath the water which takes in water and displaces the oil, the amount of displacement being regulated by spigots. This oiler dropped under a bridge in a big river or placed in a large tidal bay amidst rank vegetation produces a constantly renovated film of oil which is very effective.

Artificial containers of mosquito larvae.

In mosquito work much attention must be given to all types of artificial water containers, as rain barrels, cisterns, latrines, tin can dumps, garbage cans, gutters, water pitchers, flower vases, aquaria, table isolation receptacles in tropical countries, cesspools, sewers, toilets and flushing boxes, traps in sinks, drinking fountains, water troughs, etc. Flushing, periodic emptying, covering with oil films, stocking with fish, are among the possible expedients available in one or another of the cases. Lieut. W.L. Van Dine and Dr. W.V. King have

devised a new treatment for water in fire barrels and water tanks used for storage of water to be used in cleansing cans, in each of which cases oil is very indespensable. These receptacles may be treated with borax.

Fish as mosquito control.

Among the principal natural enemies of mosquitoes are fish and in permanent ponds, and lakes and streams the stocking with the proper species of fish may be considered as one of the most satisfactory methods of mosquito control. In this country top minnows and gold fish are commonly used for this purpose. The Bureau of Fisheries lists the following American fish available for introduction in American waters infested by mosquitoes: The killifishes, Fundulus dianhanus, F. diaphanus, F. rotatus, F. chrysotus, and F. notti; The top minnow, Gambusia affinis; Heterandria formosa, Poliemisia latipunna, Enneacanthus obesus, E. Gloriosus, Mesogonistius Chaetodon, Centrarchus macropterus, Lepomis gramilus, L. cyanellus, Elassoma zonatum, Heterigonus cryscleucas, Labidesthes sicculus, and Carassius auratus (gold fish).

The most complete summary of the species of fish available in various parts of the world is given by Hegh (pp. 140-150), Howard, Dyar and Knab and also Le Prince and Orenstein discuss the subject.

In this country any one desiring to stock a reservoir or other body of water with fish should immediately communicate with the Bureau of Fisheries at Washington,

The Panama larvicide is somewhat toxic to fishes, and undoubtedly some of the volatile oils are also, although the literature speaks only in general terms on this subject.

Destruction of adult mosquitoes.

Howard, Dyar and Knab and also Hegh cite various methods of destruction of adult mosquitoes in dwellings, such as puffing powdered pyrethrum into nooks frequented by the mosquitoes, fumigation by burning pyrethrum sulphur or cyanide fumigation, vapors of cresyl and of creoline. Le Prince & Orenstein describe a labyrinth trap for windows, quite similar to the Hodge window fly trap. Hegh figures and describes other traps.

Protection of dwellings from mosquitoes.

In mosquito sections the screening of all habitations against mosquitoes is essential. This must be done thoroughly and the screens must be carefully examined and repaired. When holes or openings occur in the screening the mosquitoes enter and are trapped and the building is often worse off than if unscreened.

For protection against Anopheles alone a 16 mesh wire screen is sufficient, but small Aedes can pass through this and therefore 17 or 18 mesh is necessary. Le Prince and Orenstein give the specifications for the 18 mesh screen to be of 90% pure copper and not more than one half of one percent of iron for damp tropical countries, the gauze having eighteen strands of wire of one one-hundredth of an inch diameter in each linear inch. In many parts of the United States other

types of wire screening are thoroughly efficient. Mr. F.C. Bishopp has for several years been making tests of serviceability of many types of screening in various parts of the country, and althouth he hasnot submitted a final report, will gladly advise anyone desiring this information for official purposes. His address is Box 208, Dallas, Texas.

Where mosquitoes are abundant the double door vestibule, arranged so that the two doors can not be opened at the same time. is highly desirable, especially for hospitals. In tropical countries with verandas around the entire house, the entire screening of the verandas is essential.

Protection of the Individual.

Campers are in the habit of using almost any thing that will make a dense smudge to drive away mosquitoes. The fumes of burning pyrethrum powder are not obnoxious to most persons and are very effective in freeing a room of mosquitoes. The powder slightly moistened and moulded into a candle will burn slowly like punk. The essential oil of the powder may be volatilized by placing on a metal screen above a lamp chimney. The odor is only slightly perceptible and not unpleasant.

For protention of the body, camphor, oil citronella, oil of cassia, and other essential oils are found efficacious. Howard, Dyar and Knab recommend as the best in their experience:

Oil of citronella	1 oz.
Spirits of camphor	1 "
oil of cedar	1/2"

This may be rubbed on the clothes or body. A few drops on a bath towel hung over the bed will keep Culex pipiens away for a whole night.

Graybill lists many repellents against flies, which have been tried on animals. The most successful substances tried by him were 50 percent pine tar in cotton seed oil, or 10 percent oil of tar in cotton seed oil,when applied lightly Fish oil is a very effective repellant. Bishopp's fish oil repellent is very effective in keeping flies from livestock when applied lightly. It consists of:

Fish oil	1 gallon
Oil of tar	2 ounces
Oil of pennyroyal	2 ounces
Kerosene	1/2 pint.

Mosquito nets for the bed are used in many parts of the South where the buildings are unscreened. Campers who sleep in hammocks may easily arrange a good sleeping net by tying a rope to the hammock supports and hanging from this a tent shaped net which can be fastened at the ends and tucked in beneath the blankets.

Hegh illustrates mosquito bars for tent coverings, for tent doors, and soldiers cots, and also a mosquito bar fastened inside a small soldiers field tent, so that the sides of the thet can be raised to give air. Various types of protective headgear have been described for troups in tropical countries, two of which are illustrated by Hegh.

The references cited below are worthy of study in connection with this lecture. There are many other works in all languages on the special problems of different countries.

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NOTICES TO CLASS.

There have been no search questions sent with recent lectures because we are at present without the necessary assistance for handling the answers. All papers on previous quizzes are being carefully graded, and from time to time other problems will be offered.

The class enrollment now numbers well over 500 and a new edition of many numbers is necessary. Members recently enrolled will have to wait a little while for these numbers, assour working force is short.

The proceedings and reports were eliminated to save paper. Letters which do not require anganswer will not be acknowledged.

A large percentage of the enrolled membership are in some branch of the service. Many of the professors expect to relay in a modified form the course to the military students in the Colleges.

It will be a pleasure if those who read these proceedings will submit their special problems for help. The bibliographies and libraries available in Washington will facilitate easy and rapid attention to these problems.

This class was organized for service and we therefore wish to meet your own particular problems as satisfactorily as possible. Official requests should be addressed to Dr. L. O. Howard, Chief of Bureau of Entomology.

W. D. Pierce,
Bureau of Entomology,

Class Leader.

PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY

OF DISEASE, HYGIENE AND SANITATION.

Lecture 19, DISEASES TRANSMITTED BY BLOOD SUCKING FLIES.

October 7, 1918. By W. Dwight Pierce.

As stated before it was necessary to discuss the transmission of diseases by flies in three lectures, non blood sucking flies, mosquitoes, and other blood sucking flies. This is therefore the third lecture on fly borne diseases, and embraces quite a different category of diseases. For convenience of reference and study it will be likewise handled from the standpoint of the organism transmitted. The most important volume on the subject of this lecture is by Hindle.

PLANT KINGDOM

THALLOPHYTA: FUNGI: SCHIZOMYCETES: BACTERIACEAE.

Bacterium tularense McCoy and Chapin, the causative organism of a RODENT PLAGUE is probably normally carried by fleas, but Wayson records some interesting experiments with the stable fly, Stomoxys calcitrans. He found that a fly after biting an acutely diseased guinea pig eight times if applied to a healthy animal within an hour, will effectively transmit the disease to the healthy animal and cause its death in five to nine days. Washings of the flies in normal salt solution, and also washings of the flies slightly crushed, when injected subcutaneously will produce similar results. The transmission by bites occurs only from those animals having an advanced stage of the bacteremia, as indicated by their death within 24 to 48 hours after the fly feeding. The flies have not been proven infective as long as 24 hours.

Bacterium anthracis Davaine, the causative organism of ANTHRAX, or charbon, can be carried by blood sucking flies. Nuttall (1899) cites many early references to the role of bloodsucking flies in the transmission of anthrax, the earliest being by Montfils in 1776, Hintermayer (1846) studied an epidemic which raged among the deer in the Park of Duttstein. The horse flies, Tabanus bovinus, T. pluviatilis, and T. coecutiens assembled usually in thousands on the carcasses of the fallen animals and sucked the sanguifluvia which escaped from the mouth, nose and vent. Leaving the bodies they immediately sought the healthy animals, thrust their proboscides soiled with the virus into the skin and in this way inoculated the poison of the disease. Mitzmain (1914) proved th at Tabanus striatus, and the stable fly, Stomoxys calcitrans, can transmit the disease by their bites. Schuberg and Kuhn (1912) transferred anthrax infection from a cadaver to a living animal through the bite of Stomoxys calcitrans.

Morris (1918) working on anthrax in Louisiana proved that the horse fly, Haematobia irritans, when biting an infected guinea pig four hours or less before its death and up to fifteen minutes after death can transmit infection. 184 experiments on different guinea pigs were made during these time limits and infection was conveyed in 34 percent of the cases. 40 experiments outside of these time limits were unseccessful. One out of two tests with the flies feeding on an infected sheep thirty minutes before death yielded infected of a guinea pig, and all tests (7) of biting in the quarter hours before nad after death of the sheep yielded infection in guinea pigs.

He also tested a species of Tabanus and proved transmission in 46 percent of 70 cases in which the flies bit between fours before death and five minutes after death.

Virulent cultures of anthrax were obtained in nature by Morris from Tabanus atratus caught feeding on a carcass. This species will feed on a carcass thirty minutes or more after death.

(The following note should have been included in the lecture on mosquito transmission of disease, p. 188. Morris experimented with the mosquitoes Psorophora sayi and Aedes sylvestris both of which commonly bite live stock in Louisiana and are very annoying. Out of 86 tests with these mosquitoes feeding on guinea pigs from three hours before death to ten minutes after death, he obtained infection by the bite of the mosquito in 40 percent).

He likewise determined the spores in the feces of the Haematobia up to six hours after feeding, of the Tabanus one to twelve hours after feeding and of mosquitoes 48 to 72 hours after feeding.

The above cited evidence should be sufficient to emphasize the absolute necessity of isolating and protecting from blood sucking insects, animals sick with anthrax. Valuable animals should likewise be kept in screened buildings during outbreaks of the disease.

THALLOPHYTA: FUNGI: SCHIZOMYCETES: COCCACEAE.

Staphylococcus pyogenes albus and aurens Rosenbach, the causative organisms of various types of SEPTICAEMIA were obtained by Joly (1898) from a Tabanus on a heifer near a mumicipal vaccine station.

Streptococcus sp., causative organism of SEPTICAEMIA was recorded from Stomoxys calcitrans by Schuberg and Büving (1914),

DISEASES OF UNKNOWN OR UNCERTAIN ORIGIN.

PAPPATACI FEVER, also known as Three Day and Phlebotomus fever, a disease of the Mediterranean Regions, which has caused considerable disability to the troops, especially in Egypt and Greece, is transmitted by the bite of the sand fly, Phlebotomus papatasii, and possibly other species in the genus. Its transmission has been clearly demonstrated by Doerr, Franz and Taussig (1909). The blood is infective for only about 24 hours. During this period the flies become infected by feeding on the patient. After ingesting the virus, there is an incubation period of seven to ten days before the insects become infective, an beyond this after an indetermined period they may again become non infective. Following the bite of an infected fly, there is an incubation period in man of from 3 1/2 to 7 days, during which time the patient is non infective. The virus is filterable. Lizards and reptiles are the wild reservoirs of the disease.

VERRUGA PERUVIANA, or Carrion's disease, a Peruvian disease, thought to be caused by Bartonella bacilliformis Strong, Tyzzer, Brues and Sellards, is claimed by Townsend (1916) to be carried by Phlebotomus verrucarum, and he advances evidence to support his claim.

EQUINE INFECTIOUS ANEMIA, or swamp fever of horses, a disease caused by a filterable virus in Japan was thought to be carried by Chrysops japonicus, Chrysozona pluviatilis, (Haematopota tristis), Tabanus chrysurus, T. trigonus,

T. trigeminut, T. luridus and T. rufidens. according to the Horse Administration Bureau (1914), and in America was claimed by Scott (1915) to be carried by Stomoxys calcitrans. Howard (1917) conducted an experiment with Stomoxys calcitrans which indicated the probability that this fly transmitted the disease.

POLEOMYELITIS, or infantile paralysis, a disease of unknown origin has been suspected by various authors of being transmitted by biting insects, especially Stomoxys calcitrans and Tabanids. Rosenau and Brues (1912) conducted experiments with this fly and reported successful inoculations of six monkeys by bites of the flies. Anderson and Frost (1912) repeated these experiments and as a result three monkeys exposed daily to the bites of several hundred Stomoxys, which at the same time were allowed daily to bite two intracerebrally inoculated monkeys, developed quite typical symptoms of poliomyelitis eight, seven, and nine days, respectively from the date of their first exposure. Autopsy of all proved the presence of typical poliomyelitis lesions, On the other hand these same authors in further experiments (1913) and Sawyer and Herms (1913) record negative results with this fly.

PELLAGRA, a disease of unknown origin, introduced from Europe to America, was for a long time thought to be caused by eating spoiled corn. At present sentiment seems to favor considering that it is caused by lack of vitamines. However, it is important that we discuss in this lecture rather briefly the theories propounded regarding blood sucking flies as possible transmitters of the disease.

Sambon (1910) brought forward the theory that the disease is carried by the buffalo gnats Simulium spp. Jennings and King (1913b) and Jennings (1914) are inclined to believe that the incidence of this genus and of pellagra affords sufficient evidence to exclude Simulium from the consideration. On the other hand Jennings and King in their three papers point out very strongly the possibility of Stomoxys calcitrans being concerned in the thansmission of the disease.

PROTOZOA.

MASTIGOPHORA: BINUCLEATA: HAEMOPROTEIDAE.

Haemoproteus columbae Celli and San Felice, the cause of PIGEON MALARIA or haemoproteasis of Columba livia, is transmitted by the pigeon flies Lynchia maura in Algeria and India, and L. brunea in Brazil. Mrs. Adie (1915) worked out the complete life cycle in the fly and Acton and Knowles (1914) in the pigeon. Mrs. Adie succeeded in transmitting the disease to uninfected pigeons by the bites of Lynchis flies. The flies used were dissected and found to contain zygotes and sporozoites. Parasites were found in the blood of the pigeons 28 days after the flies were first put on them.

In the pigeon the asexual cycle is passed. The sporozoites are inoculated by the bite of the fly. They enter the red blood corpuscles in the lung capillaries where they develop into trophozoites and schizonts and divide into merozoites, which may continue the asexual cycle by entering other corpuscles and becoming trophozoites. On the other hand they may remain in peripheral circulation and develop into the sexual forms, the macro- and microgametocytes. These forms may persist in the pigeon's blood over winter. They are ultimately taken up from the pigeon's blood by the fly and pass from its proboscis into the gut. They develop into gametes which conjugate to form zygotes in the lower portion of the

midgut. These become ookinetes and develop into oocysts in the gut wall. The oocysts divide into a multitude of sporozoites which find their way through the body cavity through the body cavity into the salivary glands and are ready for inoculation.

The life cycle is graphically shown in the chart which should be compared with that of Plasmodium in lecture 13.

Haemoproteus mansoni Sambon, the cause of HAEMOPROTEUSIS OF THE RED GROUSE, is transmitted by the grouse fly, Ornithomyia lagopodis, in which Sambon found ookinetes in the stomach.

It will be recalled that in lecture 13, certain species of Haemoproteus were mentioned as transmitted by mosquitoes.

MASTIGOPHORA: BINUCLEATA: LEUCOCYTOZOIDAE.

Leucocytozoon lovati Sambon and Seligman, the cause of leucocytozoasis of the red grouse, Lagopus scoticus, is supposed by Fantham to be likewise transmitted by the grouse fly, Ornithomyia lagopodis, in which he found vermicules.

MASTIGOPHORA: BINUCLEATA: TRYPANOSOMIDAE.

Trypanosoma sp., cause of AINO, an african disease of cattle probably identical with T. brucei, is suspected by Brumpt to be carried by Glossina lingipennis.

Trypanosoma annamense Laveran, cause of an EQUINE TRYPANOSOMIASIS in Annam is believed to be carried by Tabanidae and Hippoboscidae according to Castellani and Chalmers.

Trypanosoma brucei Plimmer and Bradford, cause of NAGANA, an African disaffecting many wild and domestic animals is transmitted normally by bites of the tsetse flies, Glossina morsitans, G. brevipalpis, G. pallidipes, G. tachinoides, and G. fusca, and may also be transmitted by the horse flies Atylotus nemoralis and a Tabanus, and by the stable fly Stomoxys calcitrans, and S. Glauca. The organism must undergo part of its development in the alimentary canal of the fly. When fully developed it is found in the proboscis and is thn capable of being iniculated into animals by the bite of the fly.

Trypanosoma caprae Kleine, cause of an African goat trypanosomiasis is transmitted by Glossina brevipalpis and G. Morsitans.

Trypanosoma cazalboui Laveran, cause of SOUMA, an African animal trypanosomiasis is principally carried by the tsetse flies Glossina palpalis, G. longipalpis, G. morsitans, and G. tachinoides, but may also be transmitted by Stomoxys calcitrans, Tabanus liguttatus, and T. taeniatus and possibly Stomoxys nigra. Development of the organism is restricted to the proboscis of the tsetse fly, the flagellates never multiplying in any other part of the alimentary canal. They may change in the proboscis into leptomonad or crithidial forms, attach to the walls of the labrum and undergo rapid multiplication. Under the influence of the salivary secretion some of these fixed flagellates develop into small actively motile trypanosomes closely resembling the blood forms. This become infective from six to ten or more days after ingestion of the parasites.

Trypanosoma cazalboui pigritia Van Saceghem, cause of ZAMBIAN SOUMA of cattle, is carried by Haematopota perturbans according to Van Saceghem who found

the organisms in the intestinal tract of flies taken on infected animals.

Trypanosoma congolense Broden, cause of GAMBIAN HORSE SICKNESS, is carried by Glossina morsitans and possibly by G. palpalis and species of Glossina, Tabanus and Stomoxys. The various forms of the parasite have been demonstrated in the alimentary canal of G. morsitans 23 days after ingestion.

Trypanosoma dimorphon Laveran and Mesnil, cause of an African ANIMAL TRYPANOSOMIASIS is carried by the tsetse flies Glossina palpalis , G. tachinoides, G. morsitans and G. longipalpis, and possibly by Lyperosia. The trypanosomes upon being taken up by the fly become established in the hind intestine and gradually extend forward until they reach the proboscis, when they become fixed and assume the leptomonad or crithidial form.

Trypahosoma equiperdum Doflein, cause of DOURINE of horses has been experimentally transmitted by interrupted feedings of the stable fly, Stomoxys calcitrans and Atylotus tomentosus by Sergent and Sergent (1906)

Trypanosoma evansi Steel, cause of SURRA of cattle and horses has been experimentally transmitted by bites of Stomoxys calcitrans, S. geniculatus and S. nigra, Either experimantal evidence or strong suspicion points to transmission by the horse flies, Tabanus tropicus, T. striatus, T. lineola, T. atratus T. fumifer, T. partitus, T. vagus, T. minimus, and other species of Tabanus and Haematopota. Certain writers have also suspected Lyperosia minuta, Philaematomyia crassirostris and Haematobia exigua. The parasite has also been found in the stomach of Stomoxys geniculatus

Trypanosoma evansi mborii Laveran, cause of MBORI, a camel trypanosomiasis of Africa, is believed to be carried by Tabanus taeniatus and T. biguttatus.

Trypanosoma franki Frosch, cause of a TRYPANOSOMIASIS OF WILD GAME in Europe is believed to be transmitted by Hypoboscidae and Tabanidae.

Trypanosoma gallinarum, cause of FOWL TRYPANOSOMIASIS of the domestic fowl is carried by Glossina palpalis according to Duke (1912).

Trypanosoma gambiense Dutton, cause of GAMBIA SLEEPING SICKNESS of man, has wild animals for its reservoir, and is principally transmitted by Glossina palpalis and its variety fuscipes. Experimental evidence indicates that it can be carried by Glossina morsitans, G. fusca, G. longipennis, G. pallidipes, G. brevipalpis, G. tachinoides as well as Stomoxys calcitrans, and the mosquitoes mentioned in a previous lecture. After the trypanosomes are ingested in the blood by the fly, multiplication begins, usually in the mid gut, After the tenth or twelfth day many long slender trypanosomes are found which gradually move forward into the proventriculus. Such long slender forms represent the limit of development in the lumen of the main gut. The proventriculus type, developed about the eighth to the eighteenth or twentieth day, is not infective; it may occur in the crop, but is not to be found permanently there. Between the tenth and fifteenth days multinucleate forms of trypanosomes are found, and may be styled multiple forms. Some of these latter may be degenerative. Long slender forms from the proventriculus pass forward into the hypopharynx. They then pass back along the salivary ducts, about sixteen to thirty days after the fly's feed. In the salivary glands they become shorter and broader, attach themselves to the surrounding structures and assume the crithidial facies. They remain attached to the wall and multiply. These crithidial stages differentiate into the short, broad

trypabosome forms, capable of swimming freely. These forms only are infective.

After inoculation into the vertebrate these forms multiply by longitudinal division. Repeated division occurs until the blood swarms with parasites. They then disappear from the blood and become latent nonflagellate bodies in the intestinal organs. These latent bodies again become flagellate and enter the general circulation, and may be taken up by a blood sucking fly. The above life cycle was worked out by Miss Robertson as well as other workers and briefed by Fantham, Stephens and Theobald.

Trypanosoma grayi Novy, cause of CROCODILE TRYPANOSOMIASIS in Africa, is carried by Glossina palpalis and G.brevipalpis

Trypanosoma nanum Laveran, cause of a fatal BOVINE TRYPANOSOMIASIS of Africa, is carried by Glossina palpalis, and possibly G. morsitans. The development in the gut of palpalis is similar to that described above for T. gambiense. Multiplication begins in the hind intestine and by the tenth day numerous parasites are found in the hind and middle intestine. The slender forms begin to be produced from the tenth to the fourteenth day onwards, and the proventriculus is usually invaded about the twentieth day. About the 25th day they invade the proboscis, where they may be found attached to the labrum, often lying in clusters. They then pass through the crithidial phase, many of them being extremely long and slender. Subsequently trypanosome forms are produced which may be found free, sometimes in the hypopharynx and at other times in the labrum. The salivary glands never become infected. (Taken from Hindle who summarizes the work of Duke and others).

Trypanosoma nigeriense Macfie, cause of NIGERIAN SLEEPING SICKNESS is possibly spread by Glossina tachinoides.

Trypanosoma pecaudi Laveran, cause of BALERI a fatal equine trypanosomiasis of Africa, is usually spread by Glossina longipalpis and G. morsitans, but G. tachinoides and exceptionally G. palpalis may be infected. Stomoxys calcitrans and S. nigra are recorded as possible carriers. The incubation period in G. longipalpis is 23 days. The trypanosomes multiply in the fly intestine up to 48 hours after ingestion in a modified form called by Roubaud the "intestinal trypanosome form". Under favorable conditions these multiply very rapidly and in seven to nine days invade the whole of the intestine as far as the pharanx. These flies are not infective until the parasites have invaded the proboscis and passed through the crithidial and leptomonad phases. These proboscis forms multiply and some reach the hypopharynx, where they assume the"salivary trypanosome form" and are then capable of infecting any susceptible animal. (Hindle).

Trypanosoma pecorum Bruce, Hamerton, Bateman and Mackie, cause of a WILD ANIMAL TRYPANOSOMIASIS is carried by Glossina morsitans, G. tachinoides, G. palpalis, and G. brevipalpis, in the alimentary canal of which it undergoes its cyclical development.

Trypanosoma rhodesiense Stephens and Fantham, cause of RHODESIAN SLEEPING SICKNESS of man is carried by Glossina morsitans, G. palpalis, and G. brevipalpis. The insect becomes infective after an incubation period of about 14 days and is infective throughout the remainder of its life. The life cycle is not completely worked out, but it is known that the trypanosomes first become established in the intestine and later invade the salivary glands. (Hindle).

M Trypanosoma simiae Bruce, Harvey Hamerton, Davey and Lady Bruce, cause of SIMIAN TRYPANOSOMIASIS is carried by Glossina morsitans and G. brevipalpis.

Trypanosoma soudanense Laveran, cause of TAHAGA of dromedaries in Sudan, EL DEDAB of dromedaries in Algeria, and ZOUSFANA of horses in Sud Oranais has been experimentally transmitted by Stomoxys Calcitrans, S. nigra, Atyoptus nemoralis and A. tomentosus.

Trypanosoma theileri Laveran, thought to cause GALL SICKNESS of cattle by some authors, was experimentally transmitted by Theiler in South Africa by bite of Hippobosca rufipes and H. maculata.

Trypanosoma tullochi Minchin, is native to Glossina palpalis in Africa, and no vertebrate host is as yet known.

Trypahosoma uniforme Bruce, Hamerton and Mackie, a fatal TRYPANOSOMIASIS of cattle, with wild animal reservoirs, is naturally carried by Glossina palpalis, which becomes infective in from 27 to 37 days. The infection of the fly in always limited to the proboscis.

Trypanosoma vivax Ziemann, cause of a bovine and ovine TRYPANOSOMIASIS is carried by Glossina tachinoides, and probably by G. palpalis and G. morsitans, Stomoxys and Lyperosia are suepected carriers. The incubation period of the fly is from five to eight days.

MASTIGOPHORA: BINUCLEATA: LEPTOMONIDAE.

Crithidia melophagia Flu is normally a parasite of the sheep tick fly Melophagus ovinus, and has been experimentally transmitted to rats and mice. Flu (1908) describes in the fly an asexual and sexual reproduction. The latter is characterised by a process of reduction, followed by conjugation with the formation of an ookinete and the infection of the eggs of the insect, which may cause a second generation of flies to carry the organism.

Crithidia nycteribiae Chatton is found in the parasitic fly, Cyclopoda sykesi.

Crithidia pangoniae Rodhain, Vanderbranden, Bequaert and Pons, occurs natutally in Tabanus hilarius, T. striatus and a Tabanus sp.

Crithidia tenuis Rodhain, Pons, Vanderbranden and Bequaert is native to Haematopota duttoni and H. vandenbrandeni in Belgian Congo.

Leishmania brasiliensis Vianna, cause of BOUBA or oral leishmaniasis of Brazil and Paraguay is believed by Brumpt and Pedroso to be carried by blood sucking flies, either Tabanidae or Culicidae.

Leishmania tropica Wright, cause of BISKRA SORE in Algeria, and BAGDAD SORE in Bagdad is believed by Wenyon (1911) and Sergent and Sergent (1914) to be transmitted by Phlebotomus minutus africanus.

Leishmania uta Escomel, cause of UTA, a dermal lesion peculiar to the west-

ern face of the Andes in Peru, is believed by Townsend to be carried by Forcipomyia utae and F. townsendi.

Leptomonas minuta Leger occurs naturally in the intestine and malpighian tubules of Tabanus tergestius.

Leptomonas phlebotomi Mackie occurs in nature in Phlebotomus minutus in India.

Leptomonas simuliae Georgewitch occurs in nature in Simulium columbaczense in Europe,

Leptomonas subulata Leger and Haematopota italica in Southern France.

MASTIGOPHORA: SPIROCHAETACEA: SPIROCHAETIDAE.

Spirochaudinnia glossinae Novy and Knapp occurs in the stomach of Glossina.

TELOSPORIDIA: HAEMOGREGARINIDA: HAEMOGREGARINIDAE:

Haemogregarina francae De Mello, a parasite of the dove, Columba livia is suspected of being carried by Lynchia maura.

Haemogregarina sp. passes its sporogony in Glossina palpalis but its vertebrate host is unknown.

Thus it will be seen that many of the most dangerous diseases of animals and some of the most dreaded human diseases are carried by blood sucking flies, and furthermore, that when the life cycles are known the transmission is principally biological, that is the insect is a necessary intermediate host. In this case the parasite invariably passes its cycle of shcizogony in the vertebrate and its cycle of sporogony in the invertebrate.

A number of organisms found only in the insects are recorded. It is quite possible that some of these will ultimately be linked up with pathological species. Any one studying disease transmission must know in advance what organisms he might encounter in the insects he is studying.

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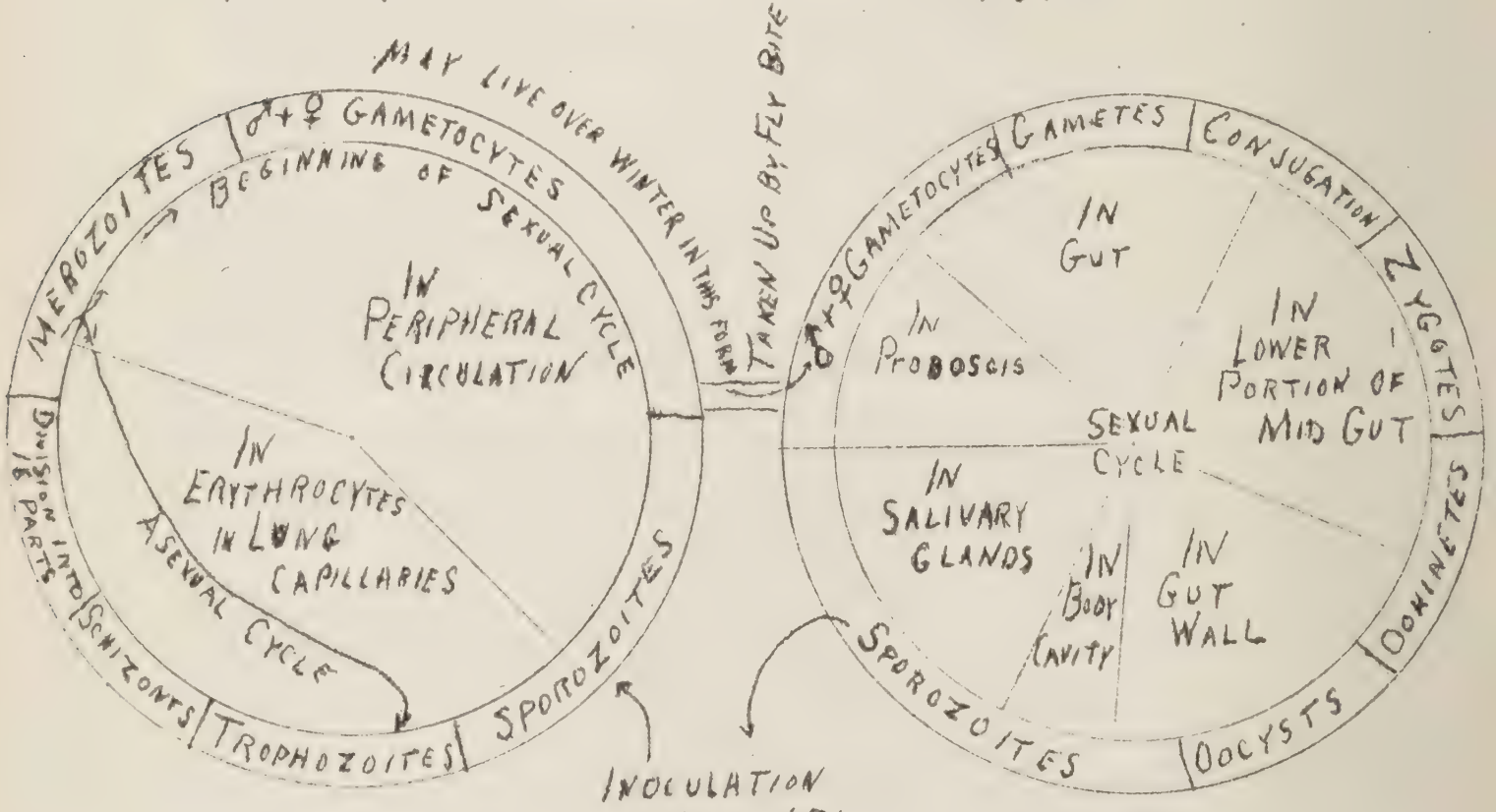
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LIFE CYCLE OF HAEMOPROTEUS COLUMBAE.

THE CAUSE OF PIGEON MALARIA.

HOST I (PIGEON) HOST II (FLY).



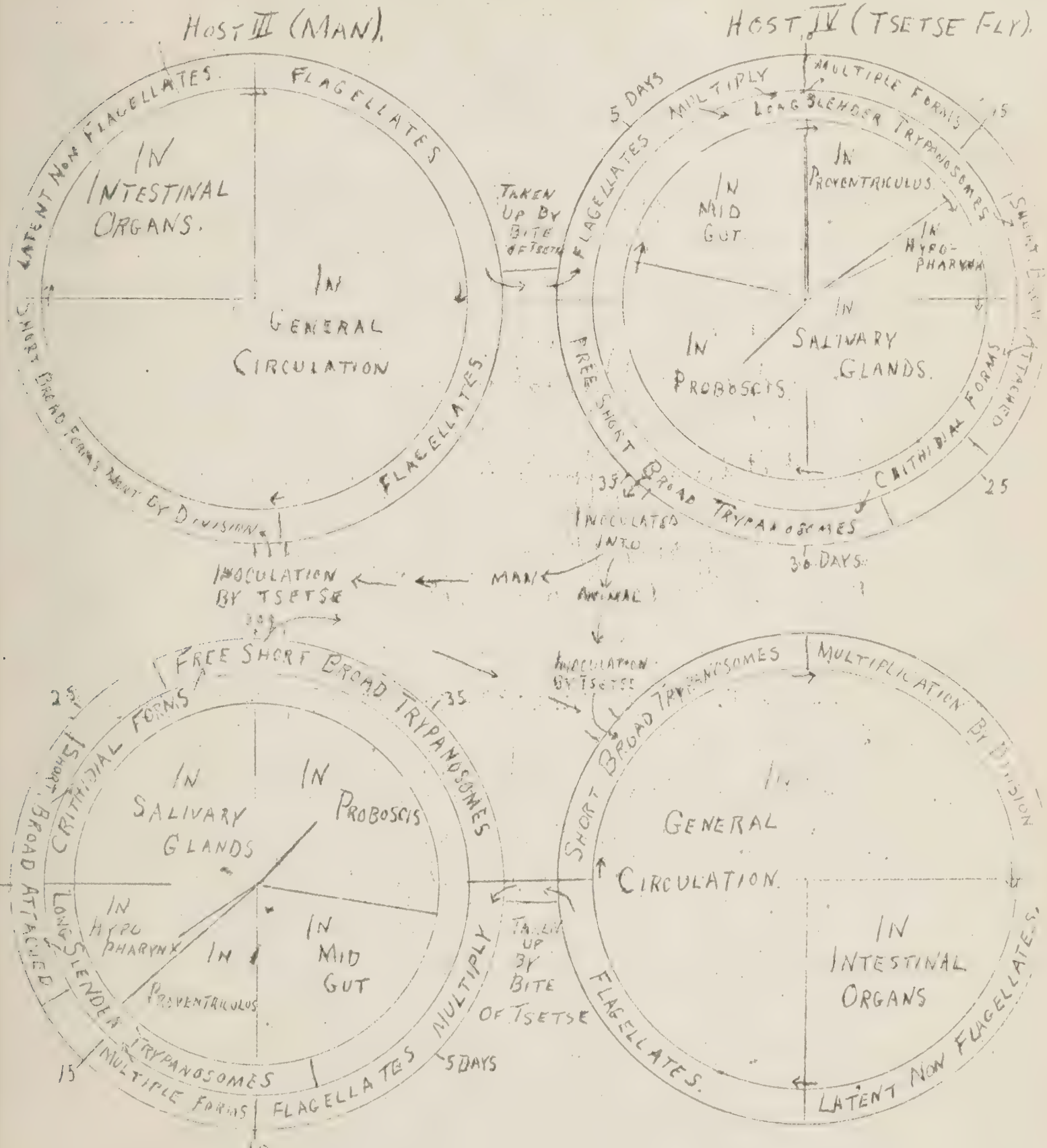
CYCLE OF SCHIZOGONY IN COLUMBA LIVIA (PIGEON).

CYCLE OF SPOROGONY IN LYNCHIA MAURA (FLY)

W. D. Prince

LIFE CYCLE OF TRYPANOSOMA GAMBIENSE.

CAUSE OF GAMBIAN SLEEPING SICKNESS OF MAN.



W. & P.

164 B.

Search Problems

16. Make an outline showing the different processes by which insects have been shown to transmit disease in the lectures already given.

17. Make for your own files a card index of diseases, organisms and insect carriers. It will be of great value to you. Report when brought up to date.

18. Without looking back at the lectures answer the following:

a. What species of Anopheles carry malaria in North America?
b. What varieties of malaria occur in North America?
c. What flies are found breeding around packing houses?
d. How can a chicken yard be kept free of flies?
e. What are some of the organisms carried by the house fly?
f. What other common non bloodsucking flies carry disease?
g. What insect carries disease but cannot transmit it unless its feces or its body is scratched into a wound?
h. What insect probably carry disease germs to humans?
i. What insects carry sleeping sickness?
j. Why is the biting stable fly dangerous?

19. If you were in charge of a packing house what measures would you take to reduce fly damage?

20. What species of disease carrying insects heretofore mentioned in the lectures occurs in your vicinity? Have you ever thought them connected with any disease outbreak not yet proven against them?

Turner

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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY

DISEASE, HYGIENE AND SANITATION.

Lecture 20, BIOLOGY AND HABITS OF HORSE FLIES.

October, 7, 1918 By J. L. Webb.

In various parts of the United States and in many foreign countries horses, cattle , and similar animals suffer severely from the blood sucking habit of the so-called horse flies of the genus Tabanus.

The life history and habits of different species may vary greatly. Yet there are certain conditions common to all species, In general, the flies of this genus are to be found in or near swampy areas of the country.

The larval stage is passed in the ground, and a certain degree of moisture is necessary for proper growth and development. Most species require very wet, or saturated soil, others are able to develop in moderately moist earth.

The eggs are deposited by the female fly in clumps of several hundred each, on vegetation, rocks, or other objects overhanging suitable places for development of the larvae. When the eggs hatch the young larvae drop to the soil or water beneath and disappear from sight. Here they remain for several months, sometimes for one or two years, when, after passing through a short pupal period they emerge as adult flies.

In some cases the egg mass as well as the place of oviposition is characteristic of the species, and renders identification easy, once the observer sees one of which he knows the identity. In the Sierra Nevada mountains of Eastern California where I have been studying tabanids for the past two years, the egg masses of the two most important species are very easily distinguished. The egg mass of Tabanus punctifer is oblong, somewhat pyramidal in shape, and about the size of the end of a man's little finger. It is usually deposited upon a bull rush or coarse grass stem, and from one to three feet above the surface of the soil. When deposited, as is the case with all horse fly eggs, the mass is milk white. In a day or so, however, the color darkens to a mottled gray and white. Eggs of this species are found most abundantly along lake shores. The eggsmass of Tabanus phaenops is to be found on grass blades, three or four inches above the soil in swam y places in meadows. This mass is considerably smaller than that of Tabanus punctifer, is elongate, and usually contains but two layers of eggs while the other species usually has about five layers. The egg mass of T. phenops is black a day or two after oviposition. These masses are inconspicuous and extremely hard to locate in nature.

In the Egyptian Sudan, Harold King found the eggs of Tabanus kingi deposited in rounded masses on rocks rising from the edge of a stream, generally overhanging the water, and from 6 inches to 15 inches above the water level. He also found the masses of Tabanus ditaeniatus on grass growing in rain pools. The shape of the egg mass of this species was variable,--some being long and narrow, others short and broad. The same worker secured ovipositions of Tabanus par in a cage, on the under sides of leaves of a water weed growing in a vessel of water. He al-

so secured the egg masses of Tabanus taeniola, the tabanid most frequently accused of causing the death of camels, from grasses and weeds overhanging rain pools. These masses were placed on the upper sides of the plants as they hung over the water.

In Ohio, Hine records finding the egg masses of Tabanus stygius principally on the leaves of Sagittaria standing in shallow water, the female fly habitually placing the eggs just above the point where the fetiole meets the expanded part of the leaf.

Mitzmain, working in the Philippines, used a large cage to secure ovipositions of Tabanus striatus. He found that egg laying invariably took place in the early afternoon, never later than 2 o'clock. Under cage conditions egg masses were deposited on projecting splinters of wood. Suspended fibers of jute sacking, fine brass wire, a single animal hair, coarse iron wire, leaves of trees, and the woodwork on sides and ceiling of the cage, invariably upon the shaded portions.-- as the undersides of beams and partitions. The egg mass in some cases entirely surrounded the object on which it was deposited. The cage contained a tank of water with growing water plants. Apparently Mitzmain did not find eggs in the open.

In Southern Nigeria, Neave found the eggs of Tabanus corax in the brush on reeds or grasses overhanging mud.

Near Alturas, California during the past two seasons, I have found the egg masses of an unidentified Tabanus, to be very abundant on the undersides of leaves overhanging a small creek. They were found on the leaves of willow, Alder, and rose bush; also occasionally on the leaves of Populus and on coarse grass blades.

I have never been fortunate enough to observe the process of egg laying, although on one occasion I came upon a female of Tabanus punctifer which had just finished ovipositing, and was still in the position, head downwards on a stem of coarse grass. She was occupied at the time in brushing the end of the abdomen over the pure white egg mass, apparently covering it with a kind of transparent cement. She was not disturbed by my close approach. In fact I broke off the stem on which she rested and observed the brushing process at close range for some little time before she took flight.

Neave mentions the fact that the eggs of Tabanus corax in Southern Nigeria are covered with an almost impervious cement. On one occasion an egg mass of this species, after being kept for two days in 70% alcohol, produced a few larvae after being taken out of the alcohol. However not all species of Tabanus cover the eggs with cement. The eggs of Tabanus phaenops in the Sierra Nevada mountains are not so covered, and fall from their place of attachment soon after hatching.

The number of eggs contained in the mass varies considerably. The easiest way of ascertaining the number in any given mass is by counting the larvae that issue therefrom. During the past summer the larvae emerging from ten masses of Tabanus phaenops eggs were counted. The number per mass ranged from 156 to 385, giving an average of 281+ per mass. Larvae from fifteen masses of Tabanus punctifer eggs were counted. The range was found to be from 159 to 701, larvae -- an average of 366+per mass. However, this method of arriving at the number of eggs per mass was very inaccurate in this case, as practically all these egg masses

were to a greater or less extent, parasitized, and in several of the masses a large percent of the eggs failed to hatch.

Larvae from a series of five unidentified Tabanus collected near Alturas, California were also counted. Here the range was from 326 to 890, - an average of 509+per mass, with no parasitism.

Mitzmain records that the number of eggs per mass of Tabanus striatus in the Philippines varies from 270 to 425. He observed the oviposition under cage conditions and found that the eggs were deposited at the exact rate of 10 per minute.

References in the literature to the incubation period are extremely scarce. King gives the period for Tabanus kingi as about 5 days, and for Tabanus par as 5 to 6 days. These species occur in the Egyptian Sudan. Neave gives the incubation period of Tabanus corax in Southern Nyassaland as about 5 days. Mitzmain determined the period for Tabanus striatus in the Philippines to be from 3 to 5 days.

In my own experinece in the Sierra Nevada Mountains I have found that the eggs of Tabanus phaenops under laboratory conditions hatch in from 6 to 7 days, while those of Tabanus punctifer require 14 days. However, in one case, a mass of T. punctifer eggs, after being kept a few days in the laboratory, was placed out doors in the sun, with the result that the incubation period was shortened to 11 days. No doubt if the mass had been kept in the open from the time of oviposition a still shorter incubation period would have been recorded. The eggs of the unidentified species collected near Alturas, California, hatched in from 7 to 8 days under laboratory conditions.

Usually most of the eggs in a mass hatch at about the same time, but in the case of Tabanus phaenops I have found straggling larvae emerging several hours after the main body of larvae were in the water at bottom of the incubator vial.

In arranging for the incubation of Tabanus larvae I am accustomed to use a large glass vial in the bottom. The egg mass is then suspended in the vial over the water, usually by placing the stem or leaf to which the mass is attached against the side of vial, and pressing a cotton stopper into the mouth of the vial tight enough to hold the egg mass in position. When the larvae emerge they fall into the water where they will remain alive for several days if undisturbed. The young larvae of Tabanus phaenops and those of the unidentified species from Alturas sink to the bottom of the water and remain there alive and in good condition, without rising to the surface for air. On the other hand newly emerged larvae of Tabanus punctifer remain at the surface of the water constantly. In all these three species the first molt occurs within a very few hours after hatching, and the coat skins are to be found floating in the water.

Mitzmain is the only author I find mentioning the molting of Tabanus larvae. He noted 3 molts in the case of the larvae of Tabanus striatus in the Philippines, as follows: 1st. molt begins with larvae 7 days old, the majority molting before the 10th day. The second molt usually occurs after an interval of at least four days, and in some larvae as much as 8 days, that is, when 15 to 18 days old. The 3rd. molt which discloses the pupa, is very variable as to the time of its occurrence, some individuals not pupating unitl 3 months after the larvae emerged from the eggs, the majorith however, pupating in a much shorter time. In fact Mitz-

main reared flies from deposition of egg to adult in 52 days.

As was stated in the beginning, the eggs are deposited above situations suitable for the development of the larvae, so that the young larvae when they drop from the egg mass immediately find themselves at home. If it is a species which lives in mud under water the eggs will be found overhanging water, and upon dropping from the eggs the young larvae will simply sink through the water to the mud beneath. If it is a species which prefers mud not submerged, the eggs will be found in the right position and the larvae upon dropping to the mud, immediately burrow into it.

The food of Tabanid larvae consists of small crustaceans and other minute forms of animal life of a soft texture. As the larvae increase in size they may take coarser food. In breeding jars I have seldom used any other food than earth worms cut into sections, and such small forms of life as may be gathered up with the mud placed in the jar. The larvae are cannibalistic and eath each other readily. Mitzmain states that the larvae of Tabanus striatus seem to prefer their own kind even when other food is available. For this reason it is well in attempting to rear larvae of this genus, to place but one larvae in each rearing jar. However, I have in some cases successfully reared more than one individual in the same jar.

Sometimes it is much easier to locate the larvae of a given species than the eggs. In most cases in my own experience I have found the larvae first. In the mountain valleys of eastern California where considerable areas of pasture land are irrigated, the larvae of Tabanus phaenops are to be found in low places where the ground is continuously wet. They are usually quite near the surface, and can be located by scratching in the mud and grass humus with the fingers. Where there is an accumulation of old dead grass matted down in water, larvae are frequently found in this grass. While this species prefers quite wet conditions it is capable of withstanding considerable drought. In making a test of drought resistence I allowed one or two breeding jars containing larvae of this species to dry out completely. One larvae survived these conditions and produced a perfect adult. The exact length of the larval stage of this species has not yet been determined.

I have found the larvae of Tabanus punctifer to be quite numerous along the shore of a lake in the Sierra Nevada mountains, There was considerable debris weeds, grass and bull rushes washed up on the shore. It was in this mass of partially decomposed vegetation kept saturated by the waves of the lake, that the larvae seemed to flourish.

Another Tabanus larvae of an unidentified species was found in the same general ~~general~~ locality in the moist earth along the sides of small rivulets high up on the lower mountainsslopes.

Prof. Hine records finding the larvae of Tabanus vivax in Ohio in the mud of a stream bed under riffles.

Likewise, King found larvae of Tabanus kingi in the Egyptian Sudan, under stones in a shallow stream where the water rippled over and around the stones, The larvae were usually found under rocks not covered by water. These larvae possessed pseudopodia specially fitted for clinging to the stones and crawling up to

the surface of the water to breathe.

The same writer found the larvae of Tabanus ditaeniatus living in mud at the bottom of a more sluggish stream, and coming to the surface of the water periodically to breathe.

King also mentions rearing adults of Tabanus par from eggs obtained in a cage. The Larvae were kept in jars of mud, and this mud was allowed to dry up several times, and for a period of 57 days no growth was made, yet when normal conditions were restored, the larvae began to grow and completed development. This is somewhat in line with my own experience with Tabanus chaenops, already mentioned.

In the Philippines, Mitzmain found larvae and pupa of Tabanus striatus in large numbers in sand at many points on the shore of Laguna de Bay.

Neave records finding Tabanus larvae in Northern Rhodesia in July and August in the sand and mud of river banks. They often occurred especially if the mud was inclined to be dry, at a depth of as much as 6 or 8 inches.

According to Hine some species of Tabanus larvae live in water for a time and crawl out into dry ground, consequently one often finds Tabanid larvae by digging in dry ground along the borders of ponds. He also states that the larvae of Tabanus stratus are sometimes found in rotten logs. It is probable that Hine uses the term "dry ground" in a comparative sense, and that both the dry ground referred to and the rotten logs, contained some degree of moisture.

The length of the larval period varies greatly in different species, and even among different individuals of the same species. The shortest periods for this stage are, found as might expected, in the tropics. Thus, Mitzmain records a minimum larval period of 9 days for Tabanus striatus in the Philippines. The maximum period is given for this species as 3 months. Neave gives the larval period for Nyasaland Tabanids as 6 months or more.

In Ohio, Hine found, in rearing Tabanus lasiophthalmus under laboratory conditions that in one instance the larval period was from June 30 to March 10, approximately 8 1/2 months. In the case of the species which I have been studying in the Sierra Nevada Mountains, the larval periods have not yet been determined, but all signs point to periods extending over two winters. As a matter of fact, data on the larval periods of species of Tabanus, are very meager.

When the time for pupation arrives the larva usually seeks drier quarters, though some moisture is usually necessary to maintain life during this period. Larvae living in the mud of stream beds usually work their way to the drier soil of the stream banks in preparation for pupation. Pupae of most species are much more difficult to locate in nature than larvae. The length of the pupal period is usually comparatively short. Mitzmain gives the period for Tabanus striatus in the Philippines as from 3 to 7 days, while King records that of Tabanus par in the Anglo - Egyptian Sudan as 6 to 8 days. Neave states that this period in Nyasaland Tabanids varies from 10 to 16 or 18 days. In rearing Tabanus lasiophthalmus in Ohio, Hine found the pupal period to be 15 days.

My records show that under laboratory conditions in the Sierra Nevada Mountains this period in Tabanus phaenops is from 14 to 22 days, while that of Tabanus punctifer is 27 to 28 days.

The shortest life cycle from egg deposition to emergence of adult, which I find recorded, is 48 days, in the case of Tabanus ditaeniatus in the Anglo- Egyptian Sudan. King gives the life cycle as 48 to 131 days.

Mitzmain found the minimum life cycle of Tabanus striatus in the Philippines to be 52 days.

The life cycle of Tabanus lasiophthalmus was found by Hine in one instance to be about 9 months. He states that the cycle of Tabanus stygins probably requires two years.

As has already been indicated in discussing larval periods, it is probable that the species of Tabanus in the Sierra Nevada mountains require two seasons for their life cycles.

Only female adult horse flies attack stock. The males are never found taking any interest whatever in warm blooded animals. Their food consists of the nectar of flowers and other sweet substances. Females also feed readily on sweet substances. I have quite often captured a few in a fly trap baited with banana. It appears that the primary object of the blood meal is to enable the female to develop eggs, although this diet may also be taken for nourishment.

The males are usually to be found in the grass, or the foliage of trees or on the trunks of trees and when the females are not sucking blood they will usually be found in the same situations.

In temperate climates females are most active on still sunshining days. It is useless to expect to find them flying on cloudy days or when strong wind is blowing.

In taking a meal of blood a female Tabanus will usually insert and withdraw the beak several times, puncturing the skin of the host in a new place each time, before finsihing the meal. The length of time occupied in taking a meal in cases observed by me has varied from about 3 to 11 minutes,and during this time the position may be changed 5 or 6 times. Mitzmain has seen Tabanus striatus in the Philippines feed for 23 minutes.

I have allowed flies to bite my arm and feed to satiety. It is not a continuously painful process. The only part of the performance that is painful is the insertion of the beek, which takes but a few seconds. After that the drawing of the blood by the fly causes no sensation whatever in the arm. However, the habit of changing position so often during a meal is somewhat annoying.

Horses are much more nervous under the attacks of Tabanus than cows. The latter often allow the flies to feed without much of any attempt to brush them off, but a horse fights constantly. Where the attack is severe, the horses in a pasture will bunch up together for mutual protection in rubbing against each other. Under such conditions it is possible that each fly will attack several horses being brushed off several times before the meal is finished. This makes an ideal

condition for the spread of disease, if there are diseased animals in the herd.

This habit of bunching up under fly attack applies also to cattle, where the attack is severe.

I have never succeeded in obtaining any data on the number of blood meals a female will take. Mitzmain states that in the Philippines, females of Tabanus striatus bite not oftener than once in 2 days.

No universal remedy, or control measure, for horse flies can be given, owing to the diverse habits of the different species. In all cases, some knowledge of the life histories and habits of the species involved is necessary, before any one can intelligently set in motion control measures, and I may say here, that the life histories of very few species of Tabanus are now known.

In some cases drainage of the larval habitat would undoubtedly be a good control measure. But the degree of drought resistance of the species in question should be ascertained before placing reliance upon this method of control,

In Russia a species of Tabanus has the habit, in the adult form, of flying to water and dipping the abdomen. Porchinski, the Russian entomologist advocates the oiling of the surface of the water as a control for this species. It appears that Porchinski has used this method with good results. He applies the equivalent of a half pint of kerosene to six square feet of water surface. If this was not sufficient to do the work, a like amount was used the next morning. It must be borne in mind however, that not all species of Tabanus have this dipping habit, and that in order to make the measure effective, the water would have to be comparatively still, as otherwise the oil would soon pass off with the current.

Occasionally the importation of egg parasites may be an effective control measure. At the present time, Tabanus punctifer in the Antelope Valley, Mono Co., California, is effectively controlled by an unidentified hymenopterous egg parasite.

Hine mentions the fact that in confinement, small catfish eat the larvae of Tabanus stygius. It is possible that the stocking with catfish streams inhabited with Tabanus larvae, might have good results.

In the way of protection of animals from the attacks of adult flies, various devices have been tried, such as nets, hoods etc. In the Sierra Nevada Mountains, I found , in one locality, a very useful horse hood in use to ward off the attack of Tabanus phaenops. This species attacks most viciously about the head and neck of horses. The hood is a simple arrangement made of light canvas to slip over the head and neck, with eye and breathing holes at the proper places.

Various repellents, mostly of an oily nature, have been tried as sprays, by different investigators, but none of these has proven very satisfactory as the effect is not lasting.

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Lecture 21. FLIES AND LICE IN EGYPT.

October 7, 1918. H.A. Ballou.

Egypt, among its other characteristics, is a land of flies. Whether they have been abundant there ever since the days of the plague of flies of Moses and Rameses may be open to argument, but there can be no doubt that in these times the abundance of flies is one of the things that strikes the visitor to the land of the Pharoahs.

I had the good fortune to live in a small village where flies were not very troublesome, and that, in spite of the fact that a fairly large veterinary camp was situated in the village. This camp was in charge of British Army officials and the village itself had been planned and built by a company, most of the stock holders and officials of which were British subjects, if not indeed actually natives of Great Britain.

The nativesvillages in the agricultural districts and the native sections of all the large cities and towns are and I suppose always have been infested with swarms of flies.

This state of affairs results from the manner of living of the people, the nature of their religion and their superstitions.

As to the first of these points, The Egyptians have always been an agricultural people, that is to say, they live on the land and by the land. Most of them are peasants or small proprietors, a comparatively few are wealthy. In the past few years a fairly large number of them has become well-to-do.

Egypt is a country practically without a rainfall. Within present geological time it has never been forested. The people throughout the whole of their history have been accustomed to live in dirt and dust, and they have not had wood for building houses or for fuel. They live in houses of sun-dried mud and they burn for fuel the manures of their domestic animals.

The space available for village sites is limited to slightly elevated spots, which are generally too high to be irrigated and are thus useless for planting, and they are to some extent above the reach of flood and infiltration of water. Very often these mounds are the covered-down ruins of forgotten cities or towns. The houses are close together, often there are no proper streets and the villages are walled about as a protection against thieves and robbers. There are usually no barns or sheds for the animals and these are housed in the houses with the family or on the house top.

The dung for fuel is mostly made up into small cakes and these are dried in the sun and stored in the houses, often in an ornamental parapet. For use in these cakes the dung of cows and the water buffalo is used. This is mixed

with leaves, straw, etc. Horse or donkey manure is used by itself mostly as a fine dry dust to produce a quick fire for baking.

It will be seen from this that the Egyptian has no idea that manure is unclean as we understand it.

In the absence of rain the Egyptian village is always dusty and the dust is a mixture of soil, manure and anything that can be dried by the fierce sun into dust.

The Egyptian has no idea of sanitation. It is one of the commonest sights in all parts of Egypt where I have been, to see in the morning hours the men squatting in the open for their morning relief.

The very wealthy and the residents in the larger towns and cities may have some form of privies, but the open field is habitual scene of operation for the great bulk of the people.

They have no more idea of the proper disposal of garbage of any sort than of the manure of their animals and their own ordure.

The moisture necessary to maintain all life in these situations comes from irrigation canals supplied by the waters of the Nile. Every village is situated on or near a canal which supplies drinking water, serves as a place for washing clothes, for bathing, and as a place for disposing of anything that is to be thrown away, from a dead calf to a broken water vessel.

As to the second point. One of the tenets of the Mohammedan religion is that the good Muslem is not allowed to take life not even of the least of God's creatures.

In connection with the third of these points, it need only be stated that the Egyptians are very superstitious about the Evil Eye. This applies particularly to the children, who must not on any account be admired or called pretty. It would be difficult to keep them clean, but nobody wants them to be clean.

It is unnecessary to give details as to the degree of fly infestation that may be seen in a native village or in the native quarters of the towns and cities. The relations of flies and children may be mentioned.

Very young children are often to be seen with their faces so covered with flies that it is difficult to tell the color of the child's skin. They swarm in the eyes, nostrils and mouth, and cover the whole face. I have often seen a small child being held or tended by another not much bigger, raise its hand to brush away the mass of flies on its face and be prevented from doing it. They are from the earliest childhood accustomed to the presence of these insects, and after being prevented from disturbing them during the early months of life they do not seem to mind them.

As a result of this condition of things, eye diseases are very prevalent in Egypt. I should not think there could be any place in the world where bad eyes are so often seen as in Egypt. The natives are often short sighted. For

instance, very few of them can read their newsparers without bringing them up to two or three inches of their eyes and then it is obvious that only one eye is used in reading. It is a curious sight to see these people reading in the trains and other public places.

This condition is probably the result of some form of ophthalmia and is quite different from the one-eyed condition so often seen in Egypt in consequence of wilful mutilation of an eye for the purpose of evading military conscription or the payment of the small sum required to purchase exemption.

THE SULTAN'S FUNERAL.

On the day of the funeral of the late Sultan, His Highness, Hussein Kamil Pasha, in October 1917, a party of us gained admission to a balcony overlooking the street in the business part of Cairo. When we arrived, there were a number of people already there. They seemed to be Italians or perhaps Syrians, we couldnt tell; they spoke French.

Among them were a number of childre, six or seven in number, the eldest being about 16 or 17 years and the youngest some 7 or 8 years of age. After a time I notices in the hair of the eldest, a girl of the brunette type with very dark hair, a whitish streak across the side of the head from near the forehead well back to where the hair was gathered into the long braid which hung down her back, This white streak must have been about an inch and a half to two inches in width and some five or six inches long. I saw that the whitish appearance was due to the presence of masses of nits of the head louse. I then noticed the heads of the other children there and found that they were all the same, Every head was full of nits.

I actually saw the lice crawling about in the hair of these children and though I watched them pretty constantly for about two hours, except for a few minutes when some parts of the funeral procession were passing, I did not once see anyone of them attempt to scratch or in any way take notice of the irritation which must have been caused by the lice, or give any indication that they were in the least aware of their presence.

The general appearance of these children was one of a fair degree of neatness and cleanliness, and yet they were so inured to the attacks of these parasites that they paid not the slightest attention to them. I have never seen anywhere such a heavy infestation of these vermin.

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Lecture 22 BIOLOGICAL NOTES ON THE BLOOD SUCKING FLIES.

October 14, 1918. By W. D. Pierce.

Mr. Webb in his lecture has given us avvery comprehensive view of the life history and habits of the horse flies of the genus Tabanus. In lecture 19 we presented the data on transmission of diseases by the blood sucking flies and by reference to this lecture it will be seen that quite a number of generalbelonging to several families of flies are concerned in disease transmission. It will be the aim of this lecture to present some of the salient biological facts concerning these genera so as to prepare the sanitarians for controlling these species in his territory, which might cause disease.

The insects we have especially to deal with in this lecture are found in the sand flies of the genus Phlebotomus in the family Psychodidae; the horse flies of the genera Tabanus, Atylotus, Haematopota, Chrysops and Chrysozona, of the family Tabanidae; the biting flies of the genera Stomoxys, Haematobia, and glossina of the family Muscidae, and the parasitic flies of the genera Melophagus, Lynchia, Hippobosca, and Ornithomyia of the family Hippobascidae.

There are of course many other genera of blood sucking flies which may contain potential disease carriers. Interesting discussions of these flies are to be found in the books by Hindle, and Patton and Cragg.

FAMILY CHIRONOMIDAE.

Midges.

The little midges of this family are often mistaken for mosquitoes to which they are somewhat related. Their young are the well known blood worms in streams and stagnant pools. Of the five subfamilies only one, the Ceratopogoninae contains blood sucking forms. The eggs of Chironomidae are small and ovoid, or long and pointed at their extremities, and are laid either in a gelatinous string of mucus or separately. The larva consists of thirteen segments, with head directed downwards, and mandibles well developed. On the ventral surface of the eleventh segment and the extremity of the twelfth, there are delicate finger like processes, usually four in number, which serve as tracheal gills. The pupa is free and either lives floating in water without any movements or rests on the bottom of the pool. It has a tuft of delicate white threads on the dorsum xxxxxxxxxxxx of the thorax, which serve as breathing tubes; or it may have a pair of respiratory trumpets.

Tersesthes torrens a mountain form in North America is a voracious blood sucker, attacking man and animals, usually on the head, ears and eyes. Its life history is unknown.

Mycterotypus bezzii and M. irritans of Southern Europe are voracious blood suckers, biting humand beings , as well as animals, and causing inflammatory swellings.

Ceratopogon is a large genus containing a number of blood sucking gnats called "punkies," found in various parts of the world. Some of the Asiatic species attack blood sucking mosquitoes and draw blood from them. It is therefore possible that these insects may play a role in disease transmission. They are very small, measuring less than 3 mm. in lenght. Only the females are blood suckers. They bury themselves often among the hairs of the host and are not recognized until they become replete with blood. They often cause great distress on account of their numbers and the irritation produced by their bites. The different species choose different parts of the host for attack, as for example some select the face, especially the margins of the ears and eyes, while others may attack the arms or legs.

Forcipomyia utae is thought by Townsend to cause the South American disease, uta. Forcipomyia is considered to be a subgenus of Ceratopogon. Larvae have been found in crab holes and below the algal crust on the sand along the sea shore in South America.

Culicoides is another large genus of midges very similar to Ceratopogon, and contains many blood suckers. Only the females bite. The larvae are found in water under various conditions. When searching for larvae where the adults are abundant they may be found by gathering in a white tray, some of the green vegetable matter found at the edges of streams. The flies can be bred by placing the pupae on moist filter paper in tubes closed with moist cotton.

The genera Johannseniella and Haematomydium also contain blood sucking midges.

FAMILY SIMULIIDAE.

Buffalo gnats.

The buffalo gnats of the genus Simulium are sometimes also called sand flies and turkey flies. This is a large genus of voracious flies which often are so numerous as to cause great distress and even death to men and animals. Sambon considered Simulium as the carrier of pellagra, but his theory has not been substantiated. Jobbins-Pomeroy has given quite a full treatment of the life history of several species of this genus and Malloch has presented a classification of our American forms. The larvae breed usually in swift flowing water.

The eggs are small rather triangular or ovoid objects, somewhat yellowish in color in a few days. They are laid in masses on grass blades, or leaves, or on stones and ohter forms of debris at the surface of the water or under the surface. The egg stage varies in each species according to the temperature, but in Jobbins-Pomeroy's studies of five species, the incubation period ranged from 7 to 13 days. A single female may lay from 500 to 1500 eggs according to published claims.

The larvae are invariably aquatic, and are quite characteristically marked by the possession of two large appendages on the head in front of the an-

tennae, which are provided with fans of long hairs. These fans serve to brush food particles into the mouth of the larva.

The mesothorax is provided with a single retractile proleg armed at its apex by a circular row of short hooklets or spines. This pseudopod with its sucker is used by the larva in attaching itself to objects. A similar but larger sucker-like disk is situated on the caudal extremity of the larvae. Respiration takes place through rectal gills located dorsally to the caudal sucker. These gills are retractile into the rectum, but are usually extended in running water. They function both as blood gills and tracheal gills, The structure of these gills affords characters of value for the identification of the species.

The larvae attach themselves by the caudal suckers and float in the stream catching their food by means of the fan-like processes on the head. When disturbed, or if the stream diminishes, the larvae let themselves float down the stream attached by a silken thread to a permanent object, by which they can regain their former position. When about to pupate the larva spins over itself a pocket shaped pupal case. The pupae are provided with respiratory organs on each side of the thorax. These are composed of long chitinous tubes with a single main stalk and four or more divisions. Good specific characters for identification are found in the structure of these respiratory organs.

The developmental period of Simulium in South Carolina is about 7 days for the egg, 17 days for the larvae, and 4 for pupa. The number of generations depends upon the species and the season and may range from one to six or more generations.

FAMILY PSYCHODIDAE.

Pappatàci flies.

The owl midges, are small moth-like flies. Only the genus Phlebotomus contains blood sucking flies, which are often called sand flies. The pappataci fly Phlebotomus papatasii, cause of papnataci fever; P. minutus, a possible carrier of bagdad sore, and P. verrucarum, supposed carrier of verruga, are the only species definitely charged with carriage of disease. Only the females suck blood. They deposit their eggs in damp dark places, in clusters or singly, to the number of from 30 to 80. The eggs are covered with a thin coating of a sticky substance which causes them to adhere to any surface. They are very elongate, dark brown, with longitudinal black wavy lines. The incubation period is from six to nine days. The larvae live in damp earth. They are very peculiar, having large well marked heads with big jaws, which have four distinct teeth. The body is covered with toothed spines and the posterior end bears two pairs of very black caudal bristles, one pair of which are as long as the body. The larva feeds on semidecaying vegetable matter. The pupa is remarkable for the large ridges and excrescences on its thorax. The larval skin usually remains adhering to the caudal extremity.

These flies breed in crevices of stone walls and fissures between rocks in caves, in dirty damp cellars,and on the damp walls of latrines and cesspools, and wherever there is damp ground in dark places. Lizards frequently serve

as blood hosts and are considered the reservoirs of the fevers carried, especially pappataci fever.

FAMILY CULICIDAE.

The mosquitoes which in an orderly arrangement would be treated here have been considered in other lectures

The families so far discussed belong to the Nematocera, the next family belongs in the Brachycera.

FAMILY TABANIDAE.

Horse flies.

The family Tabanidae, contains the horse flies, gad flies, deer flies many genera and species of blood suckers. The males throughout the family are flower feeders or feed on vegetable juices, and so likewise are the females in many genera. The eggs of Tabanidae are commonly laid in large shapely masses on the leaves and stems of plants growing in marshy ground, or overhanging water. In some species they are deposited on stones or rocks above the water of streams, and are very difficult to discover.

Mr. Webb has discussed for us the habits of Tabanus. We have seen in lecture 19 that species of Tabanus can carry the animal diseases anthrax, nagana, souma, surra, and mbori. The genus Atylotus can carry nagana and dourine; Haematopota, surra and equine infections anemia;Chrysops and Chrysozona are probable carriers of equine infectious anemia various other genera are bad bloodsuckers, especially Pangonia.

Tabanid larvae grow very slowly, feeding at first on small crustaceans which are abundant in water and moist earth. The larger larvae of many species feed almost exclusively on earth worms, whose body juices they suck out. Although the larval stage may require months for development the pupal stage will usually be short.

The flies of the family Muscidae are mostly not blood sucking flies. Principal among these genera which have the mouth shaped for blood sucking are the genera Glossina, Stomoxys, Lyperosia, Philaematomyia and Haematobia.

Blood sucking fly larvae.

The genus Auchmeromyia of Africa is very peculiar in that both larvae and adults are blood suckers. The adults are blood suckers. The adult flies are sensitive to light and are usually found in the darkest parts of the native huts. The females have two periods of oviposition about one month apart, and may deposit a total of as many as 83 eggs. They oviposit on the ground in the huts, preferably where urine has been voided. The larvae are exclusively blood feeders. They are able to resist starvation for long periods. If fed regularly they may mature in about 15 days. They remain in hiding during the day and suck the

blood ofsleepers at night. Pupation occurs in the puparium or last larval skin. The fly is probably spread from village to village in the egg or larval stage in the dirty mats which the natives carry about with them.

Travelers in Africa should always avoid sleeping in native huts of on the ground in the vicinity of corrals or native villages, because of these larvae and also many other venomous and disease bearing pests.

The African genus Chaeromyia also has blood sucking larvae which attack by larvae is not to be confused with the myiasis caused by the larvae of related genera, because these larvae are free living and do not remain attached to the host.

Biting species of Musca.

The genus Musca apparently is a transitional genus as it contains both nonblood sucking and blood sucking flies. Musca pattoni, M. Gibsoni, M. convexifrons, M. nigrithorax, and M. corvina, all of India except the last which is European, are blood sucking. But these flies are incapable of puncturing the skin of an animal. They feed on the blood and serum exuding from the bites of others blood sucking flies. These flies breed in cow dung. M. pattoni always deposits in dung where it is collected in heaps, while gibsoni aand convexifrons deposit in isolated patches of cow dung.

True biting flies.

The true biting Muscids belong to the subfamilies Stomoxydinae, Glossina, and Philaematomyinae.

Philaematomyia is a genus closely resembling Musca in appearance. It contains three Asiatic species, of which the best known is P. insignis, which only attacks cattle. It breeds in cow dung where it is collected in heaps. Both sexes feed on blood although they have also been seen feeding on cow dung. This habit would surely make it possible for the fly to mechanically carry infectious diseases from dung to blood. It breeds quite rapidly

Stable Flies.

Stomoxys is a genus found principally in Asia and Africa, although S. calcitrans, the well known biting stable fly is almost world wide in its distribution. This species is capable of carrying rodent plague, anthrax, septicaemias, nagana, souma, dourine, surra, baleri, and Gambian sleeping sickness, and has been seriously suspected as a possible carrier of equine infectious anemia, poleomyelitis and pellagra.

A very complete bulletin by Bishopp is available for free distribution, describing the life history and control of the stable fly, so that it is not necessary to give a full discussion in this lecture. It generally breeds

moist straw and hay. Stacked straw which has been wet and partly rotted and hence is no longer available for stock food is a very favorable place for the fly to breed. Such straw should be dried as soon as possible by scattering and either burned or plowed under. The stable fly does not often develop in manure, but where it does it may be controlled by measures taken against the house fly. This species is very annoying to mules, horses and cattle and often to man. Horses and mules often become frantic in their efforts to escape the flies.

As much care should be taken around army cantonments to prevent the breeding of the stable fly as the house fly. They are carriers of entirely different series of diseases and both are dangerous. Especial care must be observed to prevent breeding in straw which falls out of the stalls and windows of the stables. In one camp where the stables adjoined the road considerable straw had fallen out of the windows and lay outside the building in a place where the horses did not come, so apparently no one thought of removing this straw with the daily removal of manure. Here was an excellent place for Stomoxys to breed. In another camp and possibly several, marine weeds and debris are washed ashore and form considerable masses. Stomoxys breeds in this camp in such debris.

Horn Flies.

Haematobia sanguisugens is an Indian blood sucker which attacks cattle and horses.

In lecture 19 in the discussion of anthrax I mentioned Haematobia irritans, the horn fly. This species has been removed from Haematobia and belongs to the genus Lyperosia. Correction should therefore be made of above reference. Lyperosia irritans and L. exigua are the two commoneat blood suckers of this genus. The latter is oriental. The horn fly was treated very fully by Marlatt in a circular now out of print. This species is so called because of the habit of the adults of clustering on the base of a cow's horn. The flies also cluster on other parts of the animal and cause great annoyance. Even when not feeding the flies rest on the cattle. The eggs are laid singly on the surface of wet dung. The moment the dung is dropped a swarm of flies dart from the animal to the dung and remain there a few seconds, during which time many eggs are deposited, The flies immediately return to the cow. The larvae migrate from the dung when about to pupate and the puparia are asually found at some distnace away or under the sides of the patch of dung. The horn fly in America requires about 17 days from egg to adult.

Protection of the animal from the horn fly by the use of repellents is suggested. In this connection Grabill's bulletin on repellents should be consulted. One of the best methods of control is by the use of dipping vats and the cattle dip of the Bureau of Animal Industry, now used in the control of the Texas fever tick.

Two practical methods are available for attacking the larvae and pupae. One is to throw lime on the dung, but the better method is to spread out the dung so as to favor its rapid drying or to allow a number of pigs to run with the

cattle. In their efforts to obtain undigested food particles the pigs will effectively destroy the sung as breeding places for the fly.

Tsetse Flies.

The tsetse flies of the genus Glossina are among the most dreaded insects of Africa. They are the carriers of three or more types of sleeping sickness, of aino, nagana, souma, horse sickness, baleri, and other trypanosomiases of many domestic and wild animals. There are quite a number of species, and probably all are important, but G. morsitans and G. palpalis are the best known. Excellent discussions of each of the important species and tables for differentiation are given in the text books quoted in the bibliography.

The reproduction in this genus is very remarkable, resembling that of the Papipara and is probably the result of their exclusively blood-sucking mode of life. The female lays a single larvae at a time, which is retained and nourished in the oviduct until it is fullngrown. After the larva is born it at once burrows into the ground and pupates. The larva is generally of a yellowish white color and bears at its posterior extremity a pair of large dark colored protuberances between which is a depression into which open the spiracles. It pupates within the puparium or last larval skin. The puparium is broadly ovoid in shape and by its caudal appendages affords a means of distinguishing the species.

The habitats of the various species should be rather thoroughly studied by any one expecting service in the African tropics. In general the flies are found in moist forest regions, especially along river courses, but the temperature, moisture and shade requirements seem to vary for the different species.

PUPIPARA

The suborder Pupipara is composed of several families of the queerest flies in the order. The insects of the families Nycteribiidae, Streblidae and Hippoboscidae are all ectoparasites on warm blooded vertebrates. All of the Streblidae and Nycteribiidae of which the life history is known are parasitic on bats and some of them are quite probably the carriers of bat diseases. In the family Hippoboscidae we find the genera Lynchia, Hippobosca and Ornithomyia, mentioned in Lecture 19 as carriers of disease, and also Melophagus to which belongs M. ovinus, the sheep tick. The flies of the genus Lynchia which carry pigeon malaria live almost exclusively on Pigeons. They deposit larvae in the pigeon houses; these larvae become puparia in an hour. Hippobosca is composed principally of species parasitic on mammals, one of which is thought to carry the gall sickness of horses in South Africa. The families deposit larvae which are incapable of movement. They slowly darken until the puparium resembles a seed. Lipoptena contains deer parasites. Melophagus ovinus is a wingless fly which lives on sheep.

Outside of the stable fly control measures for biting flies are not well worked out. Of course the primary essentials are protection of the animals from the bites of the flies and prevention of breeding.

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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY

LECTURE 23 OF DISEASE, HYGIENE AND SANITATION.

October 28, 1918. DISEASES CARRIED BY ~~FLIES~~. Fleas

W. Dwight Pierce.

Fleas pass their immature stages in filth outdoors and indoors. The larvae breed in dirt and are usually to be found where animals are common, but they may breed in the dirt of kennels and stables, in the open country, in carpets, and closets of houses and especially in cellars. They are always to be found where rats or mice are common.

Because of the fact that the larva imbibes filth and the adult sucks blood, we should seek other possibilities of disease transmission which have not hitherto been investigated. All past investigations with fleas have dealt entirely with the possibility of conveying disease by the bite of the adult flea. The work which has been done on flies and which was quoted in lecture 8 showed that larvae could take up bacteria and that these would persist into the adult stage. It is therefore essential in the future investigations of disease transmission by fleas that account be taken of the possibility of the flea larvae taking up the organism from the filth in which they breed and retaining these organisms to be transmitted by the adult. That they do this is demonstrated in the case of the tape worms mentioned below.

Fleas
~~Flies~~ do carry disease, that we know. But probably they can carry diseases which they have never been credited with. There lies our field of investigation.

The arrangement of organisms transmitted by fleas follows that adopted for previous lectures.

PLANT KINGDOM.

THALLOPHYTA: FUNGI: SCHIZOMYCETES: BACTERIACEAE.

Bacillus pestis Kitasato, the cause of BUBONIC PLAGUE of man and rodents is carried by fleas. Nine species of rodents, mainly rats and mice, are proven hosts of plague. The following fleas have been proven to be carriers of the organisms, Xenopsylla cheopis, Ceratophyllus fasciatus, C. acutus, C. selentiewi, Pulex irritans, Ctenocephalus canis, Leptopsylla musculi and Pygiopsylla ahalae.

The first successful record of transmission of plague by fleas was made by Simond in 1898, and corroboration was first obtained by Verjbitski in 1903 and Liston in 1904.

Many other workers have since then proven the role of the flea in carrying this disease. A synopsis of the evidence is presented by Herms in his textbook. The flea takes up the organism with the blood of the host. The stomach of the rat flea, Xenopsylla cheopis, is capable of receiving as many as 5000 germs while imbibing the blood from a plague rat. Both males and females may carry the infection and they may remain infective during an epidemic for 20 days. The Indian Plague Commission only found the bacilli in the stomach and rectum of the fleas and never in the salivary glands or body cavity and rarely in the oesophagus. They conclude that the normal course of the bacilli is to be voided in the feces and be inoculated by scratching in of the feces. Bacot and Martin however, have come to the conclusion that plague can be transmitted during the act of biting when a temporary blocking or obstruction of the proventriculus takes place causing bacillus-laden blood to be forced back or regurgitated into the wound, thus producing infection.

Bacillus tularense McCoy and Chapin, cause of a fatal RODENT PLAGUE, which affects the California ground squirrel, Citellus beechevi may also be transmitted by fleas. McCoy and Chapin placed fleas (Ceratophyllus acutus and C. fasciatus) with an inoculated guinea pig and allowed them to remain there until the animal died. They were then collected, and crushed and inoculated into healthy guinea pigs. The four animals inoculated with crushed C. fisciatus immediately after the fleas were removed from the dead guinea pig, died of the disease; two of four inoculated after 24 hours, died; and one out of four inoculated after 48 hours died. Two out of four animals inoculated with crushed C. acutus immediately after removal from the dead guinea pigs, died, but none died that were inoculated on subsequent days, although some developed an apparently chronic form of the disease. They also succeeded in obtaining one actual case of transmission. About 100 fleas collected from an animal dead of the disease were placed in a clean cage with a healthy ground squirrel. It died 15 days later and presented the usual lesions of the plague-like disease, the bubo being in the neck.

ANIMAL KINGDOM.

PROTOZOA.

Mastigophora; Binucleata; Trypanosomidae,

Trypanosoma blanchardi Brumpt , cause of a trypanosomiasis, supposedly nonpathogenic, in rodents of the genera Myoxus and Microtus has been found by Brumpt (1913) to develop in the flea, Ceratophyllus laverani. The life cycle is identical with that of T. lewisi and T. nabiasi and is effected entirely in the large intestines of the flea. Metacyclic trypanosomes occur in the rectal ampulla and are found in the dejections. It is not found in the salivary glands.

Trypanosoma duttoni Thiroux, cause of a trypanosomiasis, supposedly nonpathogenic, in mice of the genus Mus, has been found by Brumpt (1913) to develop in the flea, Ceratophyllus hirundinis. The evolution of

This species occurs in the large intestine of the flea and is comparable to that of T. lewisi, T. nabiasi, and T. blanchardi. It is not found in the salivary glands.

Trypanosoma lewisi Kent, cause of trypanosomiasis, rarely pathogenic, in rodents of the genera Epimys, Acanthomys, Mus, Myoxus, and Meriones, etc., passes its cycle of sporogony in fleas. The life cycle has been investigated in Ceratophyllus fasciatus, Ctenocephalus canis, and Ctenopsylla musculi, and it has been shown that Pulex irritans and Xenopsylla cheopis may serve as true hosts. In addition Ceratophyllus lucifer, C. hirundinis, Ctenophthalmus agyrtes, and Pulex brasiliensis are recorded as carriers. Fantham, Stephens and Theobald summarize the life cycle in the flea. When infected blood is taken up by the flea, the parasites pass with the ingested blood direct to the mid-gut of the flea. In the stomach they penetrate the cells of the lining epithelium and multiply by division inside the epithelial cells. They first grow to a large size then form large spherical bodies within which nuclear multiplication occurs. Any one of these large spherical bodies contains at first a number of nuclei, kinetonuclei and developing flagella, the original flagellum still remaining attached for a time. The cytoplasm then divides into daughter trypanosomes which are contained within an envelope, formed by the periblast of the parent parasite. Inside the periblast envelopes are a number of daughter trypanosomes wriggling very actively; the envelope finally bursts and releases them, usually about eight, in the host cell. The daughter forms escaping from the host cell into the stomach lumen of the flea are fully formed, long trypanosomes. They then pass into the rectum, where they assume a crithidial phase, and become pear-shaped. The kinetonucleus has traveled anteriorly past the nucleus toward the flagellum. The crithidial forms attach themselves to the wall of the rectum and multiply by binary fission. In this form the parasite probably exists throughout the life of the insect. From the crithidial forms small infective trypanosomes develop. These are small, broad and stumpy, with the kinetonucleus behind the nucleus, and the flagellum longer. Brumpt (1913) declares that transmission occurs exclusively by rodents licking up the feces of infected fleas. These feces contain little metacyclic trypanosomes which are able to traverse healthy mucous.

The life cycle as described has been figured graphically in the same scheme as used in previous lectures.

Trypanosoma nabiasi Railliet, a rabbit trypanosome presumably nonpathogenic, attacks the genus Lepus and was found by Brumpt (1913) to be transmitted by the rabbit fleas Ctenocephalus leporis and Spilopsyllus leporis. The life cycle is identical to that of T. lewisi and has metacyclical forms in the rectum. It is never found in the salivary glands.

Trypanosoma rabinowitschi Brumpt, a trypanosomiasis affecting the genus Cricetus, is carried by the fleas Ctenocephalus canis, Ctenophthalmus assimilis and Ceratophyllus fasciatus. According to Brumpt

(1913) Nöller has proven the development of this organism in the rectum of fleas. The little metacyclic trypanosomes are found in the rectal ampulla.

MASTIGOPHORA: BINUCLEATA: LEPTOMONIDAE.

Crithidia ctenophthalmi Patton and Strickland, is parasitic in Ctenophthalmus agyrtes.

Crithidia hystrichopsyllae Mackinnon, is parasitic in Hystrichopsylla talpae.

Crithidia pulicis Porter (1911) not Wenyon (1908) is parasitic in Pulex irritans. Miss Porter describes its life cycle in the flea. The preflagellate stage is probably taken up by feeding on dejecta of infected fleas. The preflagellates have a somewhat frail appearance. Division rosettes are frequent. The flagellates have relatively short free flagellum and a large undulating membrane. These are followed by a post flagellate stage in which multiplication is by longitudinal division. Infection is contaminative, the postflagellates in the feces being the source of infection. There is no evidence of hereditary transmission.

Crithidia pulicis Wenyon, is parasitic in Xenopsylla cleopatrae.

Leishmania infantum Nicolle the cause of infantile kala azar of the Mediterranean region and Asia is according to experiments of Basile Probably naturally transmitted by the fleas Ctenocephalus canis and Pulex irritans. He apparently obtained the disease by taking fleas from bed clothes of infected people, and also from infected dogs, and feeding them on healthy dogs.

Castellani and Chalmers inclined towards the Basile theory but Wenyon is not convinced. Basile found Leishmania-like forms in the midgut of the flea. He also found other forms, some with flagella and some without, and concludes that there is a cycle of development with preflagellate, flagellate and post-flagellate forms.

Leptomonas species Balfour (1906) is described from Xenopsylla cleopatrae.

Leptomonas ctenocephali Fantham is parasitic in the gut of the Ctenocephalus canis. Fantham has described preflagellate and flagellate forms. In experiments of Laveran and Franchini (1913) dogs inoculated from mice infected with this organism by feeding on feces of the flea, died. The disease caused by this organism cannot be distinguished from canine kala azar, which suggests to some writers the insect origin of that disease. Fantham, however, does not consider this organism related to Leishmania.

Leptomonas ctenophthalmi Mackinnon is described as a parasite of Ctenophthalmus agyrtes.

Leptomonas ctenopsyllae Laveran and Franchini occurs in the gut of Ctenopsylla musculi of a mouse.

Leptomonas debreuili Brumpt is a parasite in the squirrel flea.

Leptomonas pattoni Swingle is native to Ceratophyllus faciatus, C. lucifer and Xenopsylla cheopis. According to Fantham and Porter it has been found naturally in the blood of mice. Ingestion of feces of fleas infected with this organism has caused death or disease in white mice according to Laveran and Franchini (1914).

MASTIGOPHORA: SPIROCHAETACEA: SPIROCHAETIDAE.

Spiroschaudinnia ctenocephali Patton has been described from Ctenocephalus canis in India.

TELOSPORIDIA: GREGARINIDA: AGRIPPINIDAE.

Agrippina bona Strickland occurs in the gut of the louse and the rat flea, Ceratophyllus fasciatus in England.

TELOSPORIDIA: HAEMOGREGARINIDA: HAEMOGREGARINIDAE.

Haemogregarinia (Hematozoon) jaculi Balfour the cause of ANAEMIA of the jerboas, Jaculus gordoni and J. orientalis is thought to be carried by the flea Xenopsylla cheopis. Balfour noted large cysts in X. cleopatrae which Christophers thinks possibly belong to this species.

METAZOA.

PLATYHELMIA: CESTOIDEA: CYCLOPHYLLODEA: TAENIIDAE.

Dipylidium caninum Linnaeus, the dog tape worm has for its intermediate hosts the dog flea Ctenocephalus canis, the cat flea C. felis, and the human flea ,Pulex irritans. It may also be carried by the dog and cat lice. Neumann, however, regards the fleas as most important. The ripe proglottids which contain the eggs of the tape worm, by their own movement, pass through the host's anus and get into the fur where they become partly dried and disintegrated. Part of the segments, the oncospheres, are released by the disintegration and are then ingested by the flea larva or the louse. Sonsino contended that the adult flea could not ingest the egg of this worm and Joyeux (1916) has demonstrated this fact. He was able to demonstrate that the larvae can and do ingest the egg easily. The embryos when they reach the intestine escape from their envelopes, the anocospheres, and penetrate the general cavity. They are imbedded in the adipose tissues and are very difficult

be found lying singly in the fat cells. The fat cells increase in size as the parasites grow, the latter being curled up once or twice within the cell, the nucleus of which remains uninjured. The embryo undergoes four stages of development in the flea. There is no positive proof of the method of transmission.

In summary therefore we may call attention especially to the fact that the flea carries plague, and is apparently the carrier of infantile kala azar, and is an intermediate host of one of the human tapeworms. In addition it is intermediate host of various animal diseases.

Unlike the louse borne diseases, the cycle of the flea borne diseases is very variable.

The bacilli of plague and rodent plague are taken up by the bite of the flea and are voided in its feces and obtain entrance to the host by the scratching in of feces or infected fleas, or by the licking up of the feces or the flea.

The five trypanosomes all are taken up from the blood and pass through a definite life cycle in the flea, passing out of its feces, and obtain entrance to the host by being licked up in the feces. This may also happen in the case of the leptomonads.

The crithidias and leptomonads belong primarily to the fleas alone and pass through their cycle of existence in the flea body and out of its feces and are taken up by feeding on the infected feces, probably by the larva.

The tape worms are taken up as eggs by the larvae feeding in filthy dirt. They develop in the flea and are taken into the vertebrate host when it licks up the flea from its body.

The filaria is taken from the blood of the host as an embryo, and develops in the flea, but we do not know how it gets back to the host.

In addition to all these diseases caused by organisms fleas may cause a dermatitis. This is especially true of the chigoe Dermatophilus penetrans, which becomes fixed to its host and sometimes even causes Ainhum, or the loss of a member. It will be discussed in the next lecture on fleas.

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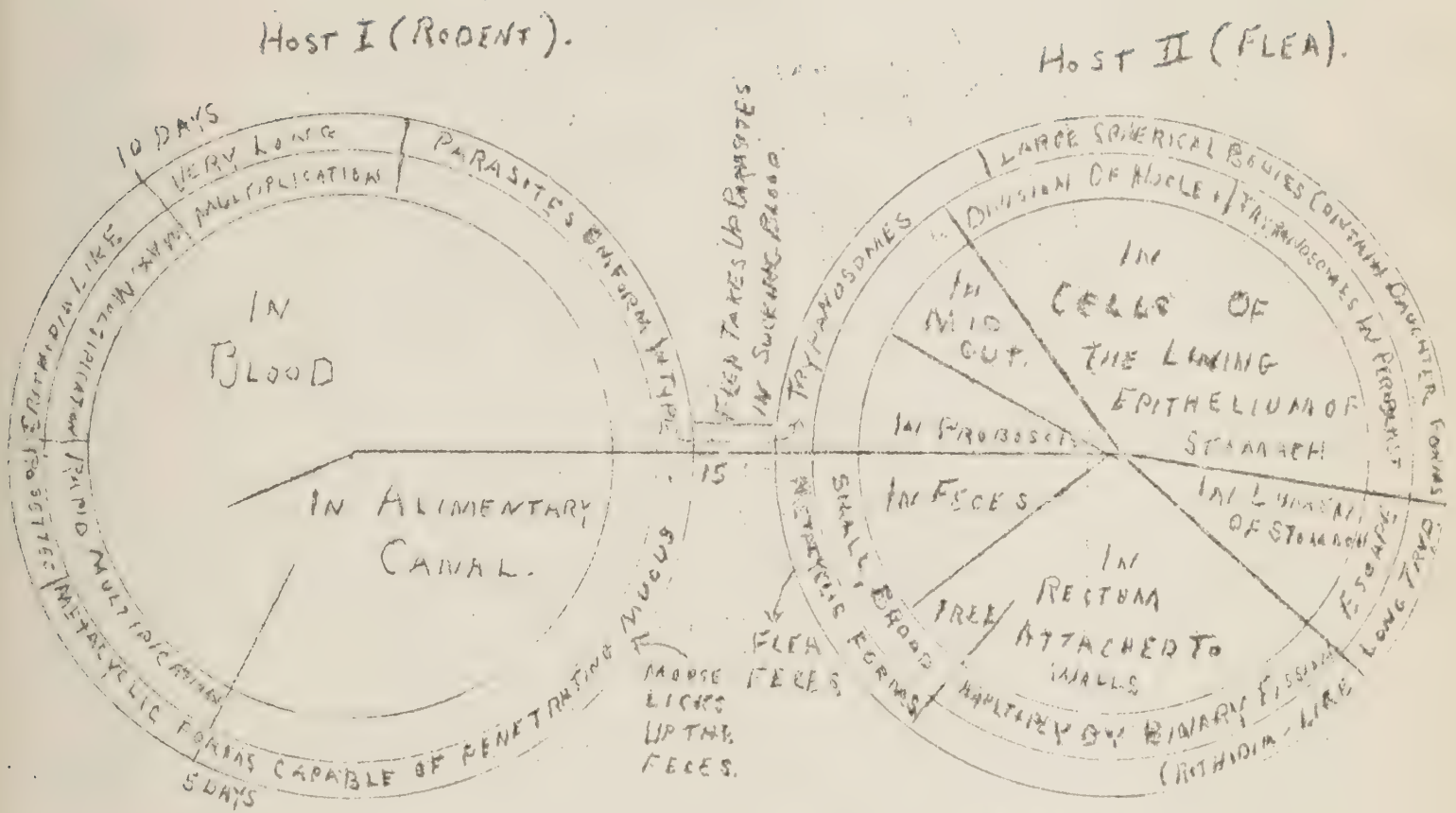
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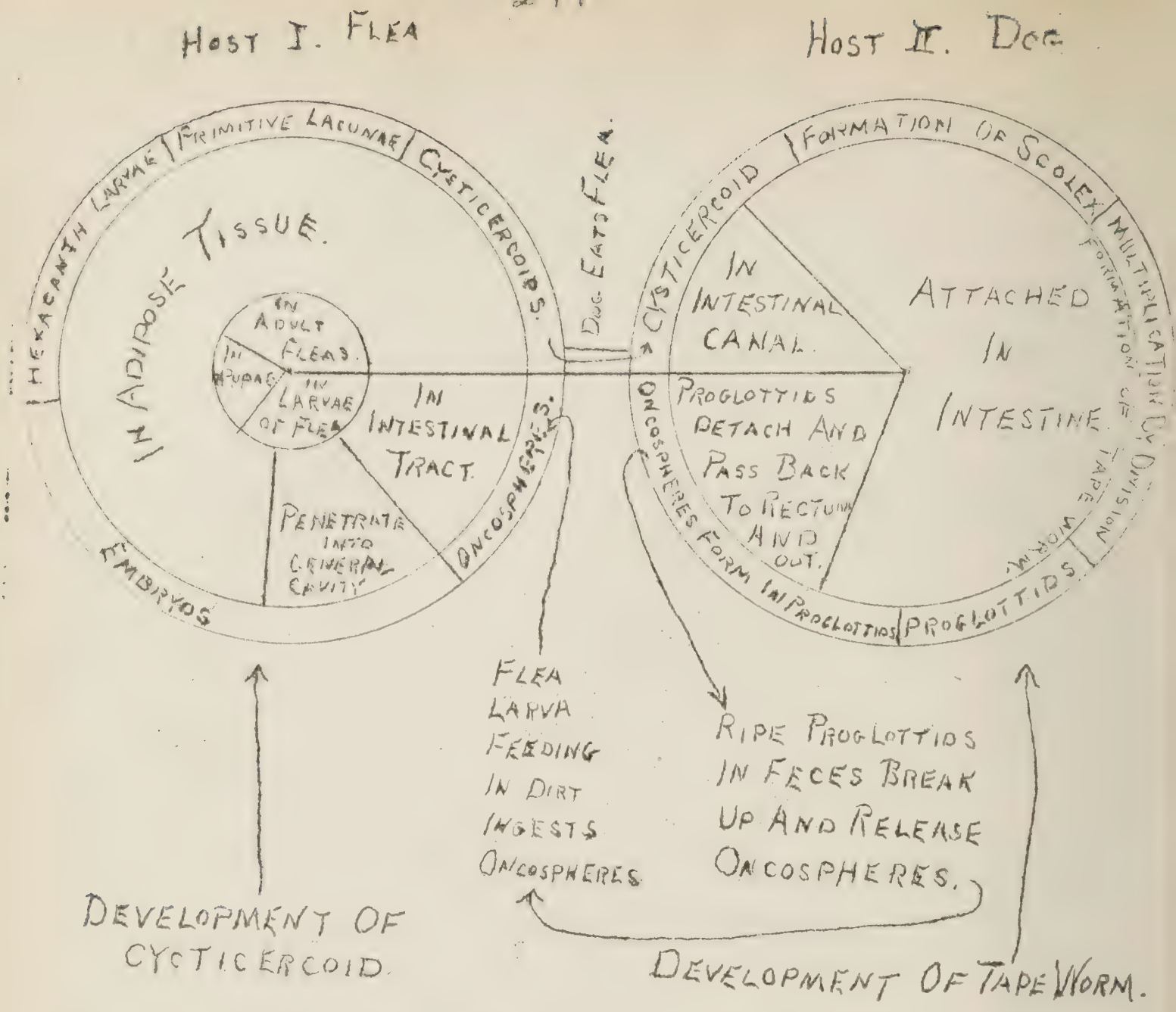
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LIFE CYCLE OF TRYPANOSOMA LEWISI

HOST I. MICE, RATS (EPIMYS, ACANTHOMYS, MUS, MYOXUS, MERIONES).
HOST II. FLEAS (CERATOPHYLLUS, CTENOCEPHALUS, CTENOPSYLLA, PULEX, XENOPSYLLA).



Life Cycle Of *Dipylidium Caninum*.

The Dog Tape Worm.

Host I. Fleas (*Ctenocephalus canis*, *C. felis*, *Pulex irritans*)

Host II. Dog (*Canis familiaris*).
Cat (*Felis catus*).
Jackal (*Canis aureus*).

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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY

Lecture 24, OF DISEASE, HYGIENE AND SANITATION.

November 4, 1918 THE CONTROL OF FLEAS.

By

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The importance of flea control probably needs no further emphasis than that already apparent after reading the lecture on the relation of fleas to disease. It should be borne in mind that the plague has been one of the most terrible scourges in the history of the world and that its reduction to an inconspicuous place in Europe and the western hemisphere has been the result of the knowledge of the relationship between rats and fleas and Bacillus pestis, the causative organism of the disease. Aside from the part which fleas play in the transmission of this dreaded malady and certain other human ailments, they are often of decided importance on account of the annoyance to man produced by their crawling about over the body and biting. The susceptibility to attack of individuals seems to vary greatly. In many cases a few fleas produce but little annoyance and the bites leave no after effect. In other instances the crawling of the fleas produces much annoyance and the bites have been known to form lesions of more or less serious character and often slow to heal.

To proceed intelligently with flea control it is important to have a good general knowledge of their habits and distribution. Eleven species of fleas have been shown capable of carrying plague. Eight of these have been found to occur on one or more species of rats (Epimys spp.) and two on ground squirrels. Of these, the Indian rat flea undoubtedly plays the principal role in the transmission of bubonic Plague. The following list includes most of the forms which may be considered important to man either as vectors of disease organisms or as annoyers: Pulex irritans, Ctenocephalus canis, Ct. felis, Ceratophyllus fasciatus, C. anisus, C. acutus Baker, Xenopsylla cheopis, X. scopulifer, Ctenophthalmus agyrtes, Dermatophilus penetrans, Echidnophaga gallinaceus, Hoplopsyllus anomalus.

The host relations of fleas is very important, as has been seen by considering the relationship of the insect to disease transmission. Unfortunately most of the fleas are not very closely restricted to certain hosts, especially when forced by hunger to seek blood. It might be stated at the outset that all fleas are dependent upon blood for their existence. There is considerable variation in the degree to which certain species are restricted as regards their host, and we should not go too far in drawing conclusions as to whether certain species will not feed on certain hosts as our judgment is usually based on a comparative-

ly small number of experiments under more or less artificial conditions or upon examinations of a small number of host species often in restricted districts.

Fleas pass through four distinct stages - egg, larva, pupa (in a cocoon) and adult. The eggs are oval, pearly white to cream in color. They are readily seen with the naked eye, especially when on a dark back ground. Most of them are deposited by the females while the latter are on the host. They fall off the host, mostly dropping in the bedding material where they hatch in from two to twelve days. This is responsible for a concentration of the adults about the sleeping places of the hosts and favors them by being within easy reach of the hosts both old, and young, and also in supplying the larvae with the partially digested blood excreted by the adult fleas, for food. The number of eggs laid varies greatly according to species, availability of food for adults, etc. Bacot, of the Lister Institute, has counted as many as 448 eggs deposited by a female human flea. Comparatively few are deposited each day but the egg laying may be extended over many weeks.

The larvae. The larvae are whitish, legless and eyeless maggots, distinctly segmented and provided with numerous hairs. They are usually less than one-fifth of an inch in length when grown and quite active, disappearing quickly in breeding material. They are to be found in the dust in which vegetable and animal particles are mixed. The larval stage is extremely variable, mostly depending on temperature, abundance of food and degree of moisture and humidity. The length of this stage has been found to range from one to twenty weeks. Under favorable conditions from one to three weeks may be taken as the usual length of this period.

The Pupa. All flea larvae spin cocoons in which the pupa is formed. These are oval and not easily seen on account of the numerous particles of dust, sand etc. which is woven in or stuck to the silken cocoon. This stage ranges from a week to nearly a year. The extreme long periods were observed by Bacot to take place only in cool weather. With the Indian rat flea the period was greatly lengthened when the mean temperature fell below 65° F., human flea below 50° F. and the European rat flea below 40 or 45° F. In cooler climates the winter is probably passed in this stage but in warmer countries adult activities never cease. The adult fleas often remain in the cocoons for weeks and emerge when disturbed.

Life Cycle. The cycle is completed under favorable conditions in one to four weeks, but it may extend to one and one-third years in extreme cases.

Length of Life of Adult Fleas. A knowledge of the length of life of the adults is of much importance in relation to control measures and disease dissemination. Under cool, moist conditions Bacot found the human flea to live 125 days, the European rat flea 95 days, the dog flea 58 days, the Indian rat flea 38 days, and the bird or chicken flea (Ceratophillus gallinae) 127 days. When fed daily this longevity was great-

ly increased: human flea 513 days, European rat flea 106 days, dog flea 234 days, Indian rat flea 100 days, and the bird flea 345 days. Mitzmain found the European rat flea to live 160 days in California and the ground squirrel flea (Ceratophyllus acutus) 64 days. In warm dry weather the longevity without food is but a few days.

The human flea (Pulex irritans) was formerly thought to restrict its attention largely to man. Investigators have found, however, that it probably develops normally on the hedgehog and others state that it is occasionally found on dogs and cats especially during the winter. Our own observations indicate that it is a very common parasite of hogs; so much so in fact that it might be called the hog flea instead of the human flea, also that it may be found in considerable numbers on dogs at all times of the year even in regions where it is not a pest of importance to man. It has been taken on several species of rats, but in limited numbers. This form appears to be well adapted to a free existence, usually leaving the host after partaking of a blood meal and this habit may tend to make it of greater importance as a disseminator of disease. It has almost world wide distribution but its abundance in different regions varies greatly. In the United States it is very prevalent in California and the Southwestern States where it is the principal cause of flea annoyance to man.

The dog and cat fleas (Ctenocephalus canis Curtis and Ct. felis Bouche') may be discussed together as their habits appear to be very similar and as some authors still believe they are not distinct species but only varieties. They have a rather wide range of hosts including the dog, cat, man, and a number of wild animals, especially of the dog and cat family. They are occasionally found on rats. They are quite widely distributed throughout the temperate and tropical parts of the world. In the United States they often occur as household pests and in the Central and Eastern States they usually take the place of the human flea as parasites of man, most of the outbreaks in these regions being from either one or the other of these species.

The European rat flea (Ceratophyllus fasciatus Bosc.) is rather closely restricted to the several species of rats and mice but it has been found to bite man in the absence of its preferred hosts and probably also will feed on other animals. It is the predominant rat flea in the United States and over the greater part of Europe, and in this region must be considered one of the principal vectors of plague. In the tropics it is much less abundant, occurring only in the cool season.

The Tropical or Indian rat flea (Xenopsylla cheopis Roth.) is undoubtedly the principal disseminator of bubonic plague in India and other parts of Asia. It is also now to be found in practically all the other tropical and subtropical countries of the world, but it is often restricted to the seaport towns, as in the case of the United States, where it appears not to have penetrated far inland. This species is primarily a rat

flea, being taken on all species of rats and mice, but it feeds readily upon man and also will attack small domestic animals and some wild ones.

The mouse flea (Ctenopsylla musculi Dugés) is to be found in many parts of the world but is especially abundant in Mediterranean Europe Australia, and the southern part of the United States. It is often found in numbers on rats as well as mice, but rarely bites man even in the absence of its preferred hosts.

The Asiatic rat flea (Ceratophyllus anisus Roth.) appears to take the place to a large extent of the European rat flea in Japan and portions of northeastern China. A species of groundhog flea (Ceratophyllus silantiewi Wagner) occurs in numbers on the "tarbagan" or groundhog in Manchuria and was thought to be concerned in the transmission of plague from that host to man in the recent Manchurian outbreak. Subsequent investigations apparently failed to substantiate this theory however.

The field mouse flea (Ctenophthalmus agyrtes Heller) occurs in England and other parts of Europe. It is common on voles and field mice and also on rats living in the open. It has no inclination to bite man. This species probably plays little part in the dissemination of plague but when the disease gets among wild rodents it no doubt would aid in spreading it from animal to animal.

Pygropsylla ahalae Roth. has been shown capable of carrying plague. It is an East Indian Island species and according to De Raadt it is abundant on rats in coffee plantations in Java, but rare on rodents in buildings. He avers that the species of fleas found on rats may be used as an index to the source of the rat population of a given place.

The squirrel fleas (Ceratophyllus acutus Baker and Hoplopsyllus anomalus Baker) are abundant in the western United States on ground squirrels. They have been shown capable of transmitting plague, and both feed readily on man and will feed on rats.

The sticktight flea (Echidnophaga gallinaceus Westw.) is an important pest of poultry in the southern United States. This species is widely distributed in the subtropical and tropical parts of the world. It attacks several wild birds in addition to domestic species and has been taken on rats in numbers. It bites man with avidity.

The chigoe or penetrating flea (Dermatophilus penetrans L.) is troublesome in the West Indies, Mexico and northern South America, and has been introduced into west Africa and from there to India. It burrows into the skin of the feet, especially around the toe nails. Many animals including man are attacked including hogs, dogs, cats and the larger domestic animals.

The flea (Xenopsylla scopulifer Roths.), occurs on rats in German East Africa. It is closely allied to X. cheopis and partially re-

places that species in the region mentioned. Its possible relations with plague transmission have not been determined

FACTORS INFLUENCING ABUNDANCE OF FLEAS.

There is a very close correlation between various climatic factors and flea abundance. This applies to practically all species in greater or less degree. In the United States it may be said that in general fleas are more abundant during moderately warm weather when there are frequent rains or high humidity. The effect of seasonal and climatic conditions on fleas has a very important bearing on the plague. This has been well shown by the Indian Plague Commission which found that there is a rather close correlation between the abundance of fleas and the prevalence of the disease, and that flea abundance in turn depended upon climatic conditions. They showed that in the case of the European rat flea there is a marked decrease in numbers with the oncoming of the hot dry season. These fleas begin to disappear in early April and from May 15 to November not a single specimen was seen. The Indian rat flea, which is the principal plague conveyor in that region, w was found to be above the mean average in number during the period from November to May, with the maximum about April. During the rest of the year - June to September - the flea prevalence is below the mean, the absolute minimum being reached in August to September, the maximum being six times less than in April. The plague season in the districts where these observations were made is from February to May, inclusive. The maximum is usually reached early in May and sudden decline being experienced with the dropping off in numbers of the fleas early in June.

The degree of annoyance to man from fleas depends to a large extent upon the relative abundance, thus in the southern part of the United States, while fleas are active throughout the year, they are reduced so low during the winter months that they confine their attacks to smaller animals. During the epring the breeding increases rapidly and often severe outbreaks are experienced. In the Northeastern States these outbreaks are more frequent during the latter part of summer and early fall.

There is also marked correlation between the character of soil and flea abundance. Sandy land is uniformly more conducive to flea development than the heavy soils. However, soils with a large amount of humus seem also to favor flea breeding. We do not expect to encounter widespread flea abundance in black land regions, but this does not interfere with severe local outbreaks.

CONTROL OF FLEAS.

The general consideration of flea control must be governed by the conditions under which one is working. When we consider regions where plague is known certainly not to exist little concern need be felt over the presence of an occasional flea and all that is necessa-

ry is to take precautions that they do not become annoyingly abundant Occasionally premises already infested may be encountered and in such. cases it is necessary to know what steps to take to reduce the numbers immediately. On the other hand, in regions where the presence of plague may be suspected the elimination of all fleas is desirable and one must give attention to the scattered fleas as well as the heavy infestations. Of course in such situations the prime move should be against the rats which act as hosts for both the plague bacillus and the fleas which carry it. In cases where the plague has become established in rural districts among ground squirrels or other native rodents their destruction requires attention also. The procedure in such cases must necessarily be governed by the duration of occupancy of a given place. For permanent elimination rat proofing is essential. This consists in the elimination of all loosely constructed buildings and the concreting of floors, basements and wharves. While the rat proofing is going on war should be waged against the rats by poisoning, shooting and trapping. Where plague is known to exist in a city or village being cleared of rats every precaution should be taken against flea bites. Workers should be provided with closely fitting clothes and leggings and certain other methods of body isolation as discussed in a subsequent paragraph.

When operating in regions where plague is suspected it is also important to choose locations for troops which are apt to be free from rats. The billeting of men in old buildings, warehouses, barns, etc. should under such conditions be entirely avoided.

Control of Hosts: To keep down heavy infestations of those species of fleas which are annoying to man and animals one of the essential steps is to exercise control over the hosts. Of course, this principle is involved in the elimination of rats and squirrels in plague areas. When an infestation is encountered the first thing that should be inquired into is the possible hosts and their haunts. Usually the main trouble can be traced to the sleeping places of dogs, cats, hogs or to hen houses or spaces beneath houses and barns frequented by poultry. In the case of the human flea the infestation may be more or less general over a premises, but there are nearly always centers where they are concentrated and often these are associated with pet animals. When the principal breeding places have been located the hosts should be destroyed if possibel or freed from adult fleas, and kept under control. A definite sleeping place should always be provided for dogs and cats and these may be kept free from fleas after treatment by cleaning out the beds regularly and spraying with coal tar disinfectant. The host animals may be freed of fleas by washing them thoroughly in a 3% solution of creolin and water or by using any other standard saponified creosote compound. Kerosene emulsion made according to the formula: one pound soap, two gallons kerosene, one gallon water, reduced one to nine is also very effective. In the case of cats these substances must be washed out of the fur with warm water and soap shortly after treatment to avoid burning the skin.

Where premises are heavily infested with adults it is first necessary to destroy this stage and this may be accomplished by fumigating, if the buildng is fairly tight, either with hydrocyanic gas: five ounces cyanide per thousand cubic feet, or by burninggsulphur at the rate of four pounds per thousand cubic feet. As has been pointed out, many adults remain quiet in pupa cases or may be buried in sand or cracks where they are somewhat protected from the effects of the gas. In destroying the immature stages we can take advantage of the destructive effect of extremes in moisture or dryness. Where complete flooding of infested areas is feasible this has been known to accomplish the destruction of all stages. In other cases, loose boards anditrash should be removed and burned and the infested areas sprinkled heavily with salt and wet down by sprinkling. Repeat the wetting operation at entervals of five to ten days, according to the condition of the soil. Usually two or three treatments are sufficient.

Where fumigation can not be practiced and it is desirable to get rid of the adults at once without waiting for them to starve a number of procedures may be followed. If in habitations, sprinkling flaked naphthalene over the floor at the rate of four or five pounds to each two or three hundred feet, closing the rooms up for a few hours, and then sweeping the material to the next room together with the stunned fleas is very effective. Pyrethrum may be used in a similar way. In barns and basements spraying with kerosene emulsion will accomplish the destruction of most of the active adults.

In buildings where fleas are breeding in the cracks of the floors or under rugs and carpets these should be removed, the house thoroughly swept and the floors washed with strong soap or lye water, or if feasible they may be sprayed with gasolene or kerosene emulsion. The free use of sweeping compounds and floor oils will largely eliminate subsequent trouble.

In treating premises infested with sticktight fleas it is important that all fowls be excluded from beneath houses and barns. These conditions prevail largely in the South where this pest becomes annoying. If this precaution is taken and the fowls are kept in shads which admit plenty of sunshine and air and the infested places be treated with salt and water no attention need be given to the fleas upon the host.

Repellents, Isolation and Trapping: To prevent fleas attacking one at night the use of flaked naphthalene or pyrethrum dusted in the bed clothing will give immunity. Sprinkling oil of tar or some similar compound on outside of clothing will give a degree of immunity, but it is better to depend on excluding the insects by wearing clothes with few external openings and wearing leggings. The wearing of shoes and leggings will largely exclude the chigoe flea. While cleaning up infested premises it has been found that the laborers can exclude the fleas and at the same time catch large numbers of them by wrapping the legs with paper covered with tanglefoot. Since fleas

are comparatively limited in their ability to jump (greatest height of any species about eight inches, greatest horizontal distance about thirteen inches) cots and beds may be protected by isolating their legs in pans of water or by wrapping them with paper or cloth treated with tanglefoot. The bed clothing should of course, be kept tucked up so as not to reach near the floor and individuals should remove all clothing and be free from fleas when entering the bed.

To prevent spread of fleas from regions where plague is present care should be taken not to allow rats and mice to gain access to packed materials and fumigation of clothing and other articles should be practiced enroute or at destination. Precautions against the transference of rats from ships to land or from the docks to ships when in port are very essential. All boats should be kept at least four feet away from the docks and all hawsers should be provided with rat guards. These are metal discs at least two feet in diameter fastened to the rope between the ship and dock. Gang planks should never be left down day or night, except when actually in use and care should taken not to transfer rats with the cargo. This is often very difficult, if not impossible.

Fumigation of ships when entering port is of course the safest plan to follow, especially if they have touched ports where plague may be present. At the present time this is pracitced in nearly all the important ports of the world. Sulphur dioxide applied under pressure by the so-called Clayton method, and hydrocyanic acid gas are employed. This fumigation if properly done accomplishes the destruction of the rats, fleas and other life aboard. The hydrocyanic acid gas appears to be giving best results and danger of damaging cargoes is lessened.

Since fleas are largely attracted to moving objects it is possible to collect great numbers of them by allowing men with their legs wrapped in paper treated with tanglefoot to walk about over the infested area. Where fleas are less abundant and especially in places where plague is suspected the use of animal hosts to collect the fleas may be employed. Guinea pigs, white rats or rabbits may be used for this purpose. After being in the infested premises for some time the fleas may be killed by placing the trap animal in a jar and applying chloroform and when the anaesthesia is complete the fleas will either drop off or remain on the surface of the hair where they can readily be picked off and placed in containers before reviving. Of course the animal may be treated with kerosene emulsion or other insecticides. The effectiveness of animals as traps varies with the species of fleas concerned. The Indian rat flea and European rat fleas do not go freely to guinea pigs but are caught in great numbers on tanglefoot on man. The squirrel flea will go to guinea pigs very readily.

Dr. Hindle has described a flea trap used in China. It consists essentially of a cylinder covered with tanglefoot and protected against sticking to objects by an outside cylinder with openings to allow the fleas to strike the sticky surface. This can be rolled about on the floors of infested rooms.

Medicinal Treatments for Flea Attack: Flea bites seldom need medical treatment. However, some people are so susceptible as to have irritation and itching following the bites and some develop ulcers. The use of disinfectant solutions are advised for the latter and cooling applications as menholized or camphorated ointments for the itching. In the case of infestations of the chigoe the insect should be promptly removed by excision and the part kept as free from infection as possible.

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Notes On Dermatophilus penetrans

W. H. Pierce.

Mr Bishopp has mentioned the chigoe in his lecture but I believe this exceedingly interesting flea is deserving of a more extended statement. In South and Central America it is also known as La Nigua. It breeds in the flesh of man and animals, attacking the pig, cow, goat, sheep, horse, dog, cat, lion and gorilla, and probably other vertebrates.

When the female is impregnated she attaches herself to the skin, bores in and remains stationary. When the eggs are mature they are either passed out while the female is fixed to the skin, or the flea may become detached. The female while attached swells to a great size. The larvae breed in dust and pupate in a cocoon. The favorite points of attack are on the heels, balls of foot, palm of hand, and between the fingers, although they attack other parts of the body.

The attack is very painful, and in severe cases may result in ainhum, the loss of a member. Brumpt says this flea frequently inoculates the germs of tetanus, Bacillus tetani. This belief is also held by Duros who notes the large number of cases of tetanus following nigua attack.

In cases of heavy infestation Duros uses a pomade composed as follows:

Salicylic acid	——	2.5 grams.
Petiol (ichthyol)	——	10.0 grams.
Yellow vaseline	——	10.0 grams.

In a few days the infested area encrusts and falls off leaving the skin free from parasites.

In cases which might call for amputation Duros baths in petroleum. He advises against the use of iodine, which is dangerous in these cases.

Prevention of breeding, restriction of hogs from wandering around habitations, wearing of shoes, cleanliness are prophylactic measures.

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OF DISEASE, HYGIENE AND SANITATION.

Lecture 25. CATTLE LICE AND THEIR CONTROL.

November 11, 1918.

By
G.H. Larson, Jr.

Nearly every species of animal bearing hair or feathers is subject to the attack of from one to a dozen species of lice. A given species does not infest all kinds of animals, but is confined to certain related kinds.

Lice are divided into two ordinal groups according to their method of feeding. One order, the Mallophaga, includes biting lice like the bird lice and the small red lice on dairy animals, which feed on the dry skin hair or feathers but do not suck the blood. The other order, the Siphunculata, the sucking lice, fatten themselves by sucking the animal's blood. These of course are the most annoying injurious and dangerous. Some of the sucking lice under certain conditions may transmit fatal disease but none of the cattle lice are known to do this. The present bulletin deals only with the species which infest dairy and beef cattle.

The place where stock is kept, has a part in the degree of infestation, for cows that are placed near other badly infested cows have a greater opportunity for becoming lousy than those that are stabled with cattle that are comparatively free from lice. Where lice have occurred year after year there is a greater danger of infestation than where the stables have been kept clean, well ventilated and well lighted. The lice cannot maintain life for any extended period of time away from the cows. If stables are kept clean, well lighted and ventilated there is somewhat less danger of infestation.

Too much stress, however, has been placed upon the condition of bedding and stables and not enough upon the condition of the stock for it is doubtful if any cows is ever entirely free from lice for the whole year, even where the stables are kept scrupulously clean and well managed. Careful examination of the infested herd will show that there is considerable difference in the number of lice on different cows, some are very badly infested and infested early in the winter while others will have a few lice on them and others will seem to be free.

The degree of dryness of the skin is often closely related to the numbers of lice on the different cows. When cows are not in good physical condition this results in a lack of natural oiliness of skin and makes conditions ideal for lice to increase. It will be noted that the variations in the numbers of lice on cows varies with the breed,

that Holsteins are notably among the most infested, that Avrshire and Gurnseys are intermediate and that Jerseys are not so badly infested. Calves which have less oily skin secretion than older stock are more generally infested with lice.

There is a marked difference in the season of the year when lice are more numerous. The skin secretions are reduced in the winter and it is then that the lice are most numerous. In the summer only a few can be found. Certain cows in a herd will be infested early and will continue infested through the winter. The fact that Holsteins being usually either black and white or having the combined markings, make the lice more conspicuous, seemed at first, to offer a solution for the reason why they have been generally conceded to be the most infested breed of cows, yet considerable study has borne out t the fact that this is due to the general lack of skin secretion of the breed. For these reasons it is believed that not only should we try to keep the stables clean, well lighted and well ventilated but also keep the stock in good physical condition. The fact that the lack of oiliness of skin tends toward lousiness indicates a logical control measure for these parasites.

The Parts of the Body Infested.

Cattle lice are by no means uniformly distributed over a cow, particularly if they are of the sucking species. The upper portions of the neck, shoulder tops or withers, escutcheon and the switch of the tail are usually the parts that are infested with the largest numbers.

The forehead, portions between the horns, and the throat are places where the lice are next most likely to be found. It is these places, especially the upper portions of the neck and withers, that the dairymen should watch for indications of their presence and it is to these places that the insecticide or control measure should be applied most liberally and most thoroughly. While the small red biting lice move about somewhat, the sucking lice remain stationary during the greater portion of the time before reaching maturity, feeding continually.

SPECIES OF CATTLE LICE.

1. SUCKING LICE.

The short-nosed cattle louse, Haematopinus eurysternus Mitzsch, is the best known of the cattle lice. It is very broad and measures in the female about one-eighth to one-fifth of an inch, while the males are alittle smaller and a little narrower,

The eggs or nits are white and can be distinctly seen glued tightly to the hairs along the shoulders. From thirty-five to fifty eggs are laid by the mature female and these are laid a few each day. The egg laying period may extend over a period of ten to fifteen days. These eggs

hatch in from seven to eight days and the young lice commence drawing the cow's blood near the point from which they were hatched. The rate of growth depends somewhat upon the blood supply in the portion of skin where they work. They mature in from fifteen to eighteen days when the females in turn lay eggs.

The Long-nosed Cattle Louse, Haematopinus vituli Linnaeus is often spoken of as the "blue louse," or the louse attacking calves, though it occurs frequently on older stock. It is distinguished by being darker in color and slender in shape with a long pointed head. When seen on the cattle it seems to be literally standing on its head with mouth-parts buried in the skin feeding on the blood of the animal that it infests. It is found more commonly on the neck and shoulders of the animal.

The mature insects are a dark bluish gray in color giving them an appearance of being either blue or black and they are about one-eighth of an inch long. Their color and their small size allow them to pass unnoticed especially on stock of a darker color. If one will turn back the hair until the skin of the animal can be seen, their presence may be made out by the shining surfaces of the abdomen. If they can be made out on the calves having white markings they can be usually assumed to be present on the others or there should at lease be a close observation of all the calves.

The eggs of this louse are dark, nearly black and hatch in from eight to nine days. Like the previously mentioned species these lice move about but little before maturity but continue feeding near the point where they were hatched. They in turn lay eggs in fifteen to eighteen days.

BITING LICE.

The Little Red Cattle Louse, Trichodectes scalaris, Nitzch is perhaps the most generally found on cattle. It seems to be out of place as it is of the biting group and this group is most commonly found on birds. It feeds on the hair and loose scales of skin and the drier the skin of the cow, the more numerous these lice become, until they can be made out by the thousand, closely matted in the hair. They are most commonly found on the neck and shoulders though in bad cases they are found pretty generally over most parts of the animal.

Unlike the two previously mentioned species they move about considerably among the hairs having feet well adapted for this purpose.

These lice are small yet visible with the naked eye measuring about one-thirtieth of an inch. They are reddish in color having distinct bands across the abdomen. The general shape of the body is quite different from that of the sucking lice for their heads are broad and blunt while those of the sucking lice are much more pointed.

used for protecting vaccination points were used to confine the lice. Areas were shaved leaving small tufts of hair on which the lice could breed and adhesive tape bound the caps to the calf. The electric incubator kept at the approximate temperature of the cow's skin was used to supplement the observations made on the animal itself.

CONTROL MEASURES.

A control measure or remedy for cattle lice in order to be practical must be cheap, reasonably easy to apply, effectice in killing the lice and at the same time do no injury to the cow. It should not be so poisonous that the accidental consumption by animals would endanger their life. At the same time the material used for control should be commonly sold and thus be within the reach of purchasers even in the remoter country villages.

Clipping. Clipping the stock over the portion of the animal most likely to be infested is not an uncommon practice and where the hair is long and the animal is very badly infested it helps to bring the oil or wash where it will be most effective. We have found, however, that animals that have been clipped are more liable to show a considerable scurfing of the skin because the application reaches the skin more quickly and in larger quantities than when it is held on the hair and thus reaches the skin gradually. There are those who feel that the animals do not look as well when clipped.

If control measures are used early, thoroughly, and repeated throughout the winter clipping will be unnecessary.

REMEDIES.

Raw Linseed Oil. Of the many different measures for the control of lice on dairy cows and young stock raw linseed oil gave the best results from the stand-point of economy of material and labor of application, killing the lice, but not injuring the skin and at the same time not making it necessary to thoroughly drench the cow. It had no poisonous properties. At the same time it is a logical remedy as the lack of oiliness in the skin of the cow is a fundamental reason for her being lousy. Linseed oil can be put on at the time taken for grooming or cleaning the cows thus doing two things in one application. From four to five cows can be treated with a pint.

Raw linseed oil can be best applied with a brush having bristles of unequal length of which the rice fiber brushes are probably most durable. When applied with a sponge the hairs coming from shedding become matted on the sponge making application a little more difficult.

It takes about five minutes to apply linseed oil to the cow's coat and a slight oiliness will remain for several days which is a

desirable feature. On some animals the loose skin may scurf or lift giving one the impreseion that some little irritation has been caused, yet if one will give the condition study he will see that there has been no inflammation or reddening of the tissues but that the loose epidermis has lifted.

The use of raw linseed oil as a control for cattle lice is neither new nor patent. It has been used by scores of dairymen in the past with good results, others have used it once and expected that application should last for the whole year and have been anxious to get some one treatment that would do for all time. A few others have possibly noticed a slight scurfing of the skin from some animal and have decided that it was burned by the application. If, however, raw linseed oil is applied in the right manner and repeated at necessary intervals it will be found to be one of the most effective agencies for the control of cattle lice and will save time, labor, and injury to the animals.

The use of boiled linseed oil is not recommended as there is some little danger of burns in using it, particularly if it is rubbed forcibly into the skin.

To avoid the danger of scurfing or burning the skin observe the following directions. Do not rub the skin too vigorously when applying the oil. Do not allow the animals that have been treated to go out in the strong sunlight until at least twelve hours after applying the oil. Do not exercise the animal after the treatment. Do not cover the cow. Do not use the boiled or refined linseed oil.

Linseed oil is used internally for other purposes and is a safe remedy if properly applied.

SPRAYS.

Many dairy men practice spraying cows and some have obtained good results from using spray materials such as creolin, kerosene emulsion, tobacco solution, and arsenical washes. A small bucket pump answers for this spraying. Thoroughness is essential and it is sometimes necessary for two or three to work on the same animal at the same time brushing the spray material into the hair before it runs off.

Creolin: Of the materials used for spraying cows a solution of creolin is one of the most common. The strength should not be less than four per cent to kill the lice and not more than five per cent as this will cause some scurfing. A four and one-half per cent will give the best results for creolin.

Kerosene Emulsion: This emulsion has been used with satisfactory results by some dairymen. It is made by shaving one-half pound of laundry soap in one gallon of soft water that has previously been brought to the boiling point. When the soap is all dissolved remove fr

from the fire and add two gallons of kerosene oil. Stir this thoroughly and if you have a bucket pump place this in the mixture turning the nozzle back into the bucket so the material is constantly passing through the pump. This will form a cream emulsion. If any free oil separates from this mixture continue pumping until the oil ceases to show. Then mix this amount with twenty gallons of water and apply either with a spray pump or with a brush, preferably the former. In using kerosene emulsion we have observed that the lice were not killed with a mixture that was so weak that it would not do injury to the skin of the animals to which it was applied. For this reason the linseed oil gives much better results.

Some dairymen do not take care of the lice on their cows because they feel that spraying is the only method that will reach these insects and that the danger from the animals catching cold after such a treatment more than offsets the injury of the lice. There is but little danger of cows catching cold if they are in good health, particularly if the day is not too cold and if the cows are covered well after the treatment.

Our trials indicate that with the average material such as creolin, kerosene emulsion or an arsenical wash, together with the labor factor the cost is about ten cents per animal for each treatment.

There are some disadvantages in this treatment, however, among them the labor and time factor, the amount of equipment necessary and the fact that a number of these sprays are not effective enough to kill the lice or they are too strong for the cow's skin or that the effectiveness does not last for any considerable time after the application. These control measures are listed and their advantages and disadvantages mentioned.

Arsenical washes: Arsenical washes are also used for the control of cattle lice but owing to the great care necessary in using them both from the danger of poisoning and the possible injury that may occur by using them too strong or in applying them too vigorously, it has been felt that less dangerous applications can be made with even better results.

One thing can be said for them however, and that is regarding their effectiveness. That the lice are killed by the application of arsenical washes there is no doubt.

One formula recommended is as follows:

¼ lb. caustic soda (85 per cent pure)
1 lb. of white arsenic (99 per cent pure) fine powder
5 lb. of sal soda
½ pint of pine tar.
30 gallons water

In preparing and using any arsenical dip or wash one should remember that arsenic is a poison and take precaution to avoid injury. If animals are allowed to drain where they may drink the solution or feed when the solution is dripping off of them they are liable to be poisoned.

Care should be taken too that the hands should not be exposed any more than necessary.

The arsenical washes may be necessary to use for dips for large herds and under range conditions but their use is questioned for smaller herds.

For fuller information regarding arsenical dips and washes for cattle on range see Farmer's Bulletins No. 608 and 909.

Nicotin washes. These are questionable owing to the fact that extreme care must be taken in order to keep the wash away from the cows so that they will not get some of it internally. Cows are particularly susceptible to poisoning from tobacco decoctions.

Greases: Mercurial ointment is one of the most effective of lice killers though it is very liable to cause burns even when it is diluted considerably. This was used on some cows diluted with twelve parts of vaseline and burns resulted from its application. Kerosene oil and lard have been used considerably for cattle lice but the danger of injury to the skin with the use of kerosene oil, unless it is very thoroughly mixed with some dilutant, is always present.

With the majority of the greases the lack of spreading properly makes their application expensive because of the quantities of material necessary to cover the regions infested by lice.

Powders: Dusting powders are usually sulphur, naphthalene and pyrethrum. These are not recommended. Cattle lice are too difficult to control for such methods to be effective.

TIME FOR THE APPLICATION OF CONTROL MEASURES.

Though cows are infested with the largest numbers of cattle lice during the months of January and February, yet the measures for their control should be applied long before that time, in fact, they should be used within a week after they have been brought into the barn for the fall and winter. A second application should follow twelve or thirteen days afterward. The purpose of these two applications is to rid the cows of the lice that are on them before they become numerous and spread to more susceptible animals. The lice may not be seen at this time but the dairymen should not reason that the lice are not present. This gives a proper length of time for all of the three species of cattle lice to hatch from eggs but not long enough for them to lay eggs again and be in a resistant stage where the

treatment will not reach them.

Treatment should be repeated at intervals of a month from the second treatment. In case animals show any great number of lice, treatment should be given and repeated in twelve or thirteen days.

Treatments with linseed oil can be made at the usual time when the cows are being groomed and cleaned.

control From five to six treatments during the fall and winter should control the lice in the average herd.

SKIN INJURIES.

One of the most troublesome phases of the study of the control of cattle lice was to determine the strength of insecticides that would kill the lice but would not injure the skin, thus causing the hair to come out badly or making distinct burns.

The skin of the cow is very susceptible to injury when compared with the skin of other animals. It is known that cows have been killed by the application of certain insecticides recommended for the control of cattle lice. This indicates that caution must be taken in the use of control measures that have not been sufficiently tested. Caustic washes cannot be used without danger of their doing considerable injury unless they are very accurately measured and applied very carefully to the skin of the animal.

It is known that exposure to direct sunlight and active exercise after application contributes to cause skin injury with nearly evry one of the control measures for cattle lice.

It is doubtful if there is any application that will kill lice on cows that will not cause a slight degree of scurfiness on the cows at times. If one will look at a condition of scurfiness carefully he will find that loose portions of the epidermis has lifted and fragments are thick in the hairs yet there is no irritation or reddening of the tissues hence no real injury. Scurfiness is a condition that may occur without any application to the skin and it should not deter the dairyman from using a control measure that does not cause a real injury but may cause the unguarded to fear that after all there is no control measure for cattle lice that will not at the same time cause burns to his stock.

Scurfiness passes in a short time and leaves the skin clean underneath.

PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

CAMP SANITATION METHODS.

By the courtesy of Admiral E.R. Stitt and of Dr. W.L. Mann Post Surgeon, Marine Barracks, Quantico, Va., it is possible to distribute to the class four pages of illustrations of sanitary methods used at Quantico which are of interest to entomologists as well as sanitarians. Briefly these illustrations may be described as follows:

Doctor Ebert's Submersible automatic bubbler fountain consists of a cylindrical tank which is sunk below the level of the water. Through the water intake the water flows and displaces the oil which bubbles out at the oil outlet. The amount of oil released will be gauged by the spigots.

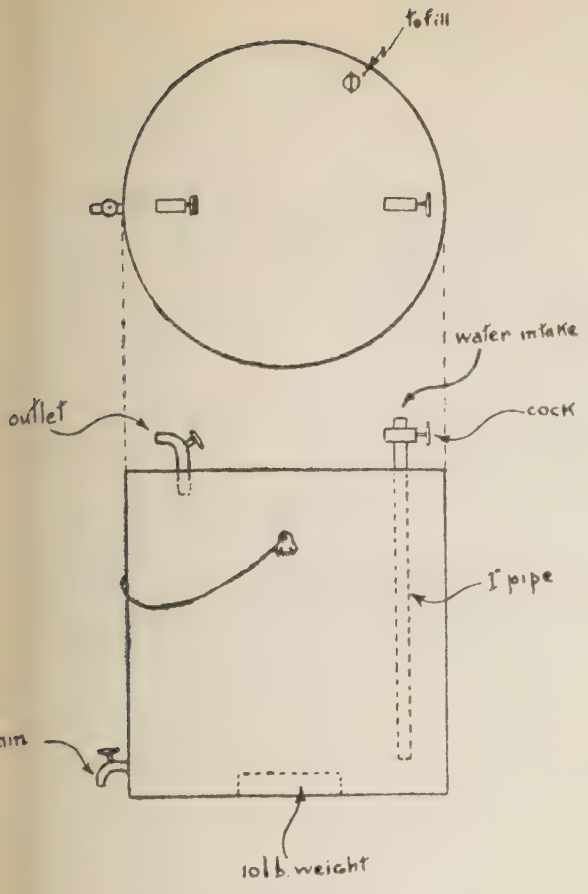
Dr. Ebert's sawdust mentod of distributing oil has many modifications. In the illustration the method followed is the placing of a box containing oil impregnated sawdust in the stream, arranging it so that the water will flow through the sawdust and carry off a tiny film of oil. Dr Mann's hillside incinerator is illustrated in two forms, one being on the hillside and the other an excavation from level ground. These are both easily understood.

The figures of the urinals and latrines are self explanatory.

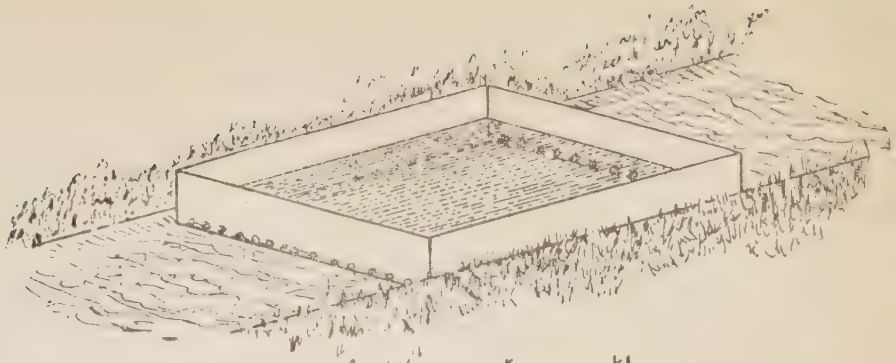
NOTICES TO THE CLASS.

The course will be concluded with the last Monday in December, and then the entire series of lectures will be revised up to date, with some additional numbers, and printed. If any member has an original contribution suitable for inclusion, it will be welcomed. Original illustrations are desired and will be credited to the contributors.

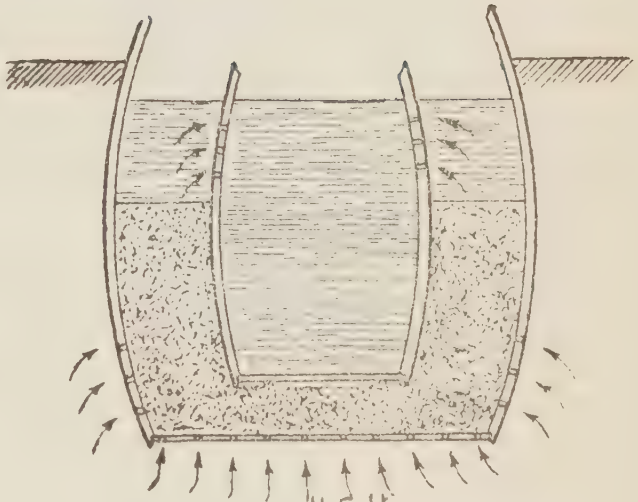
Those who enrolled late did not receive all back numbers. We have just mailed out these numbers to all cases noted by us. If you lack any numbers we can now fill out your sets. The present distribution exceeds 500 copies.



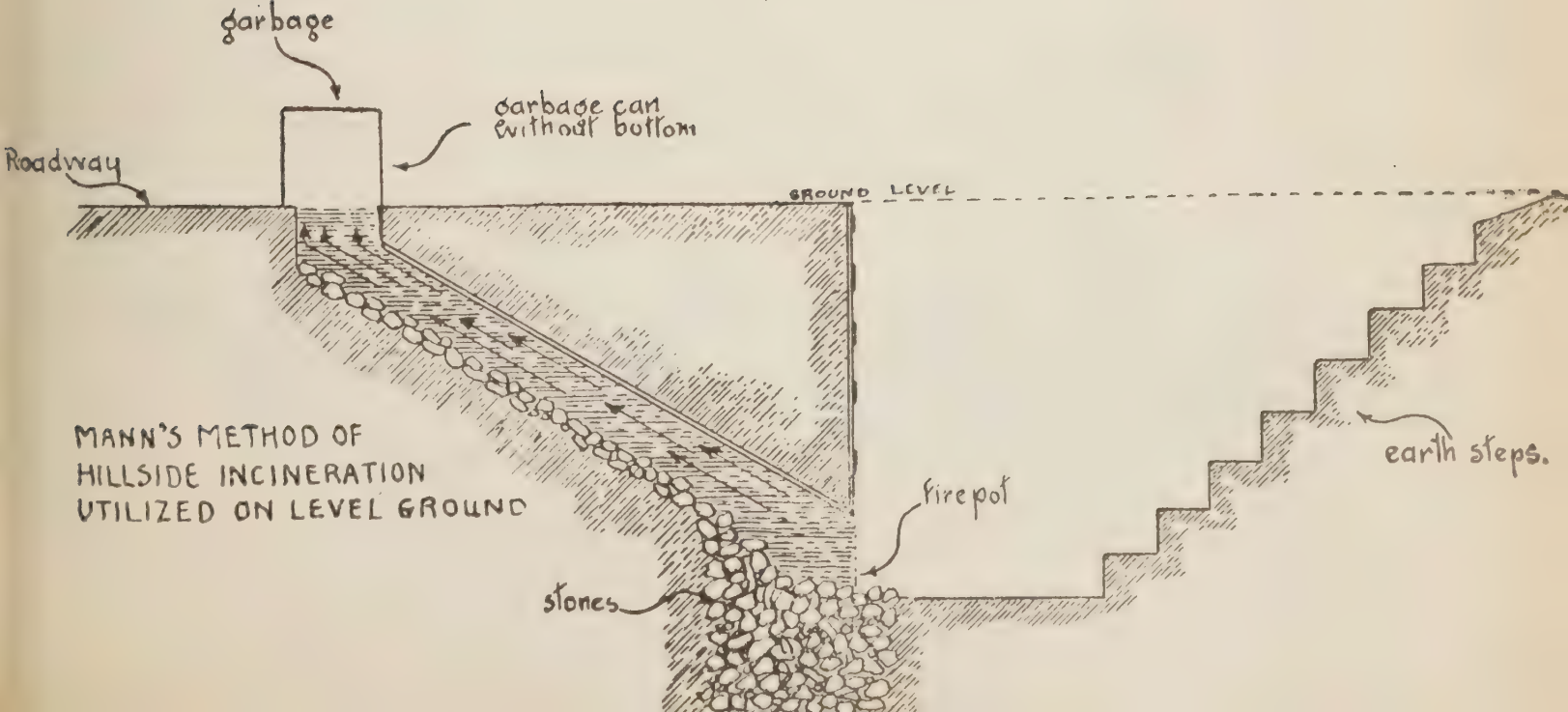
EBERT'S
SUBMERSIBLE AUTOMATIC OIL BUBBLER



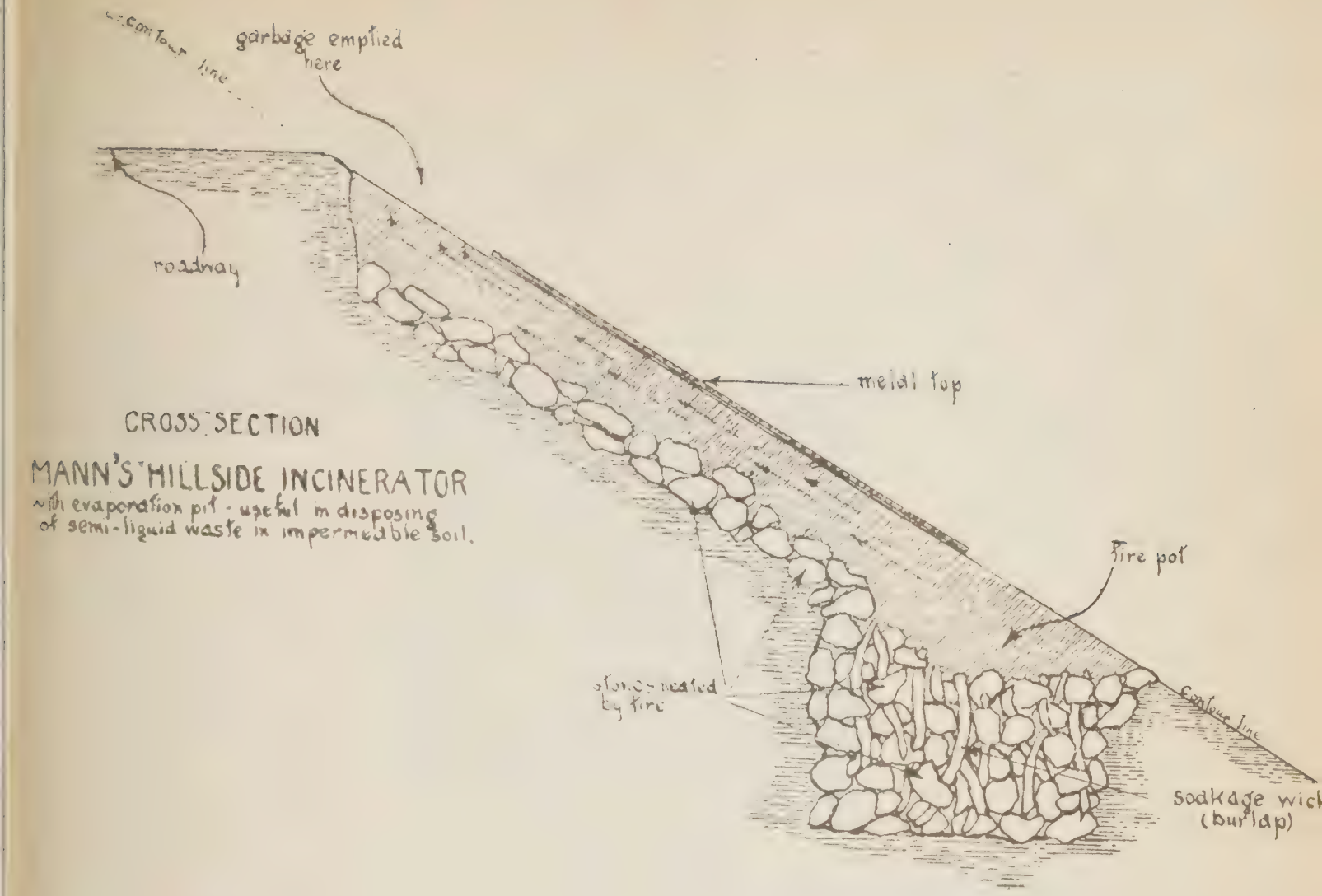
Method of petrolization with oil soaked sawdust originated by Asst. Surgeon E. C. Ebert



Barrell Filter
sunk in spring



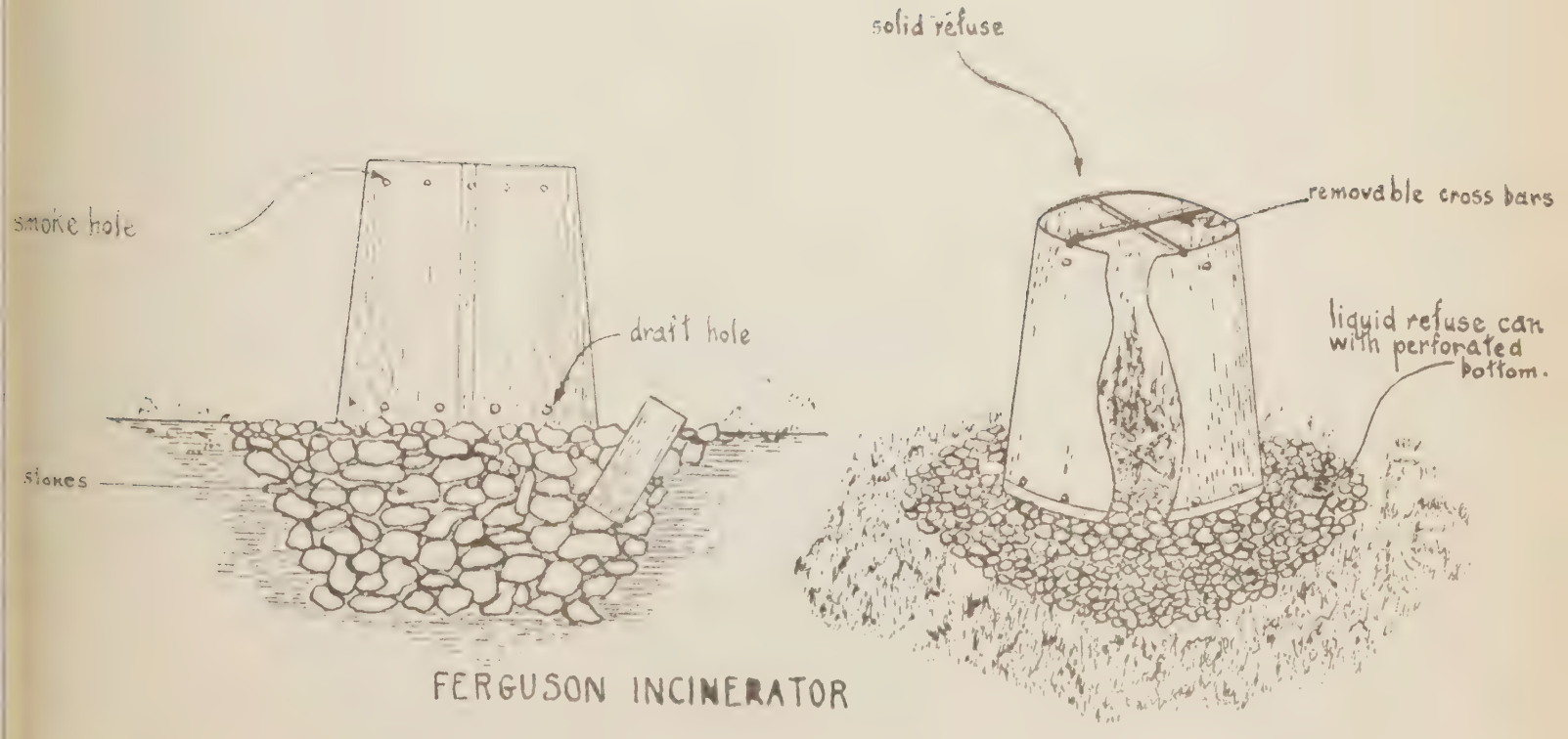
MANN'S METHOD OF
HILLSIDE INCINERATION
UTILIZED ON LEVEL GROUND



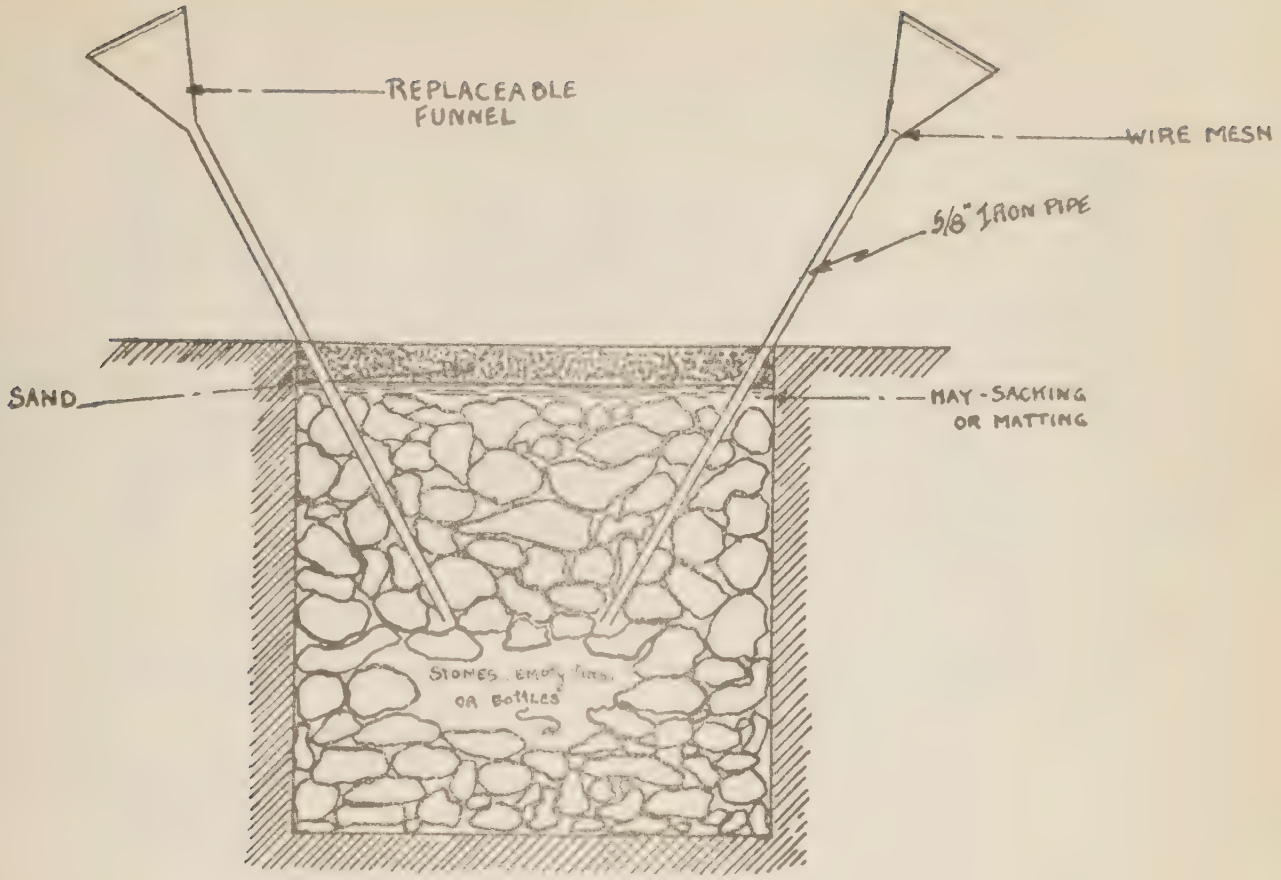
CROSS SECTION

MANN'S HILLSIDE INCINERATOR

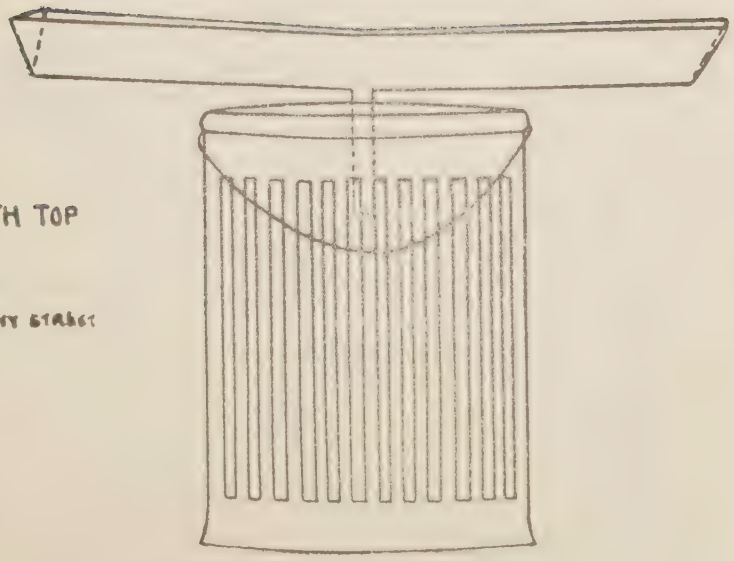
with evaporation pit - useful in disposing of semi-liquid waste in impermeable soil.



FERGUSON INCINERATOR

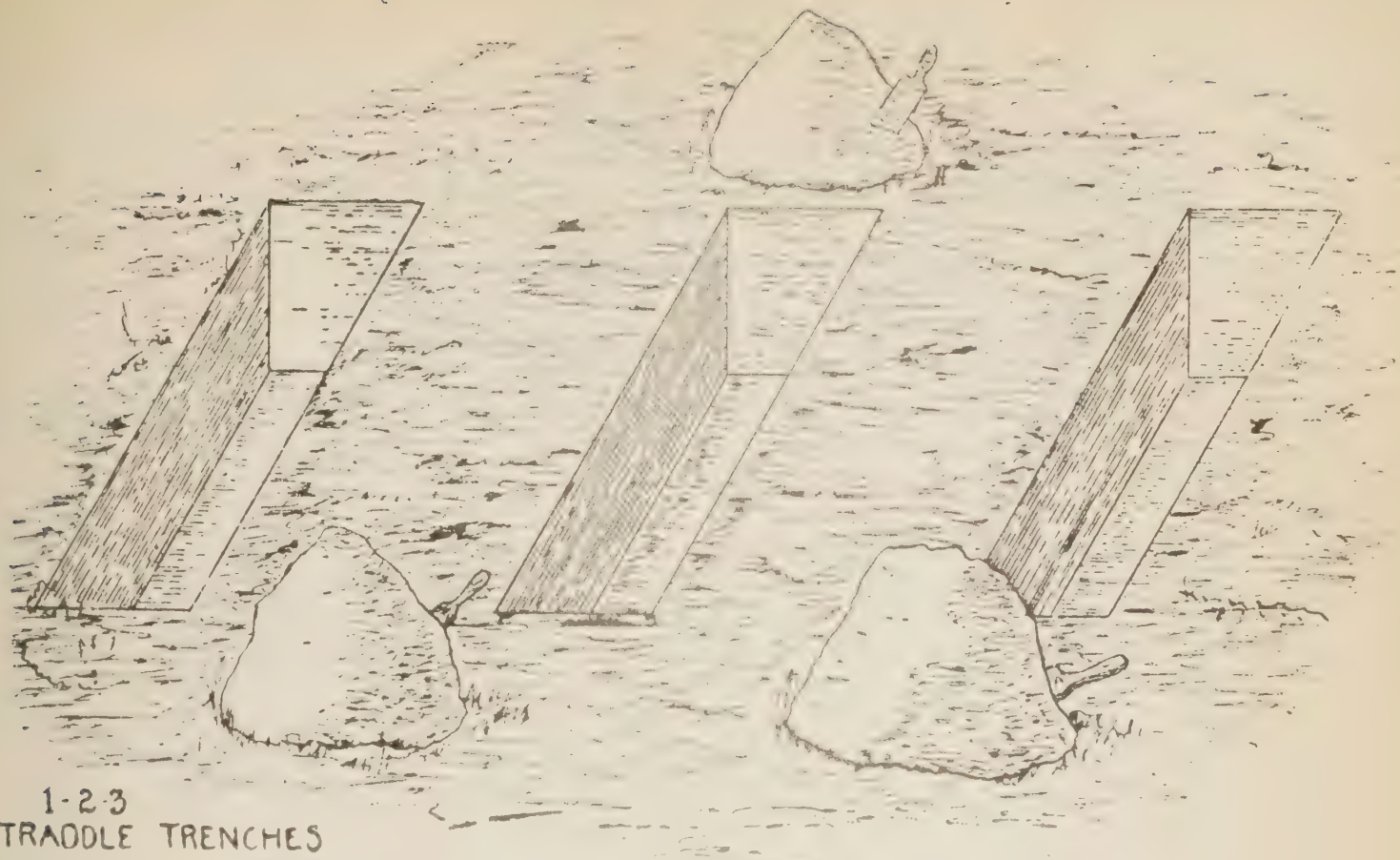


CROSS SECTION
URINE SOAKAGE PIT - MANN'S MODIFICATION
FROM - LELEAN -

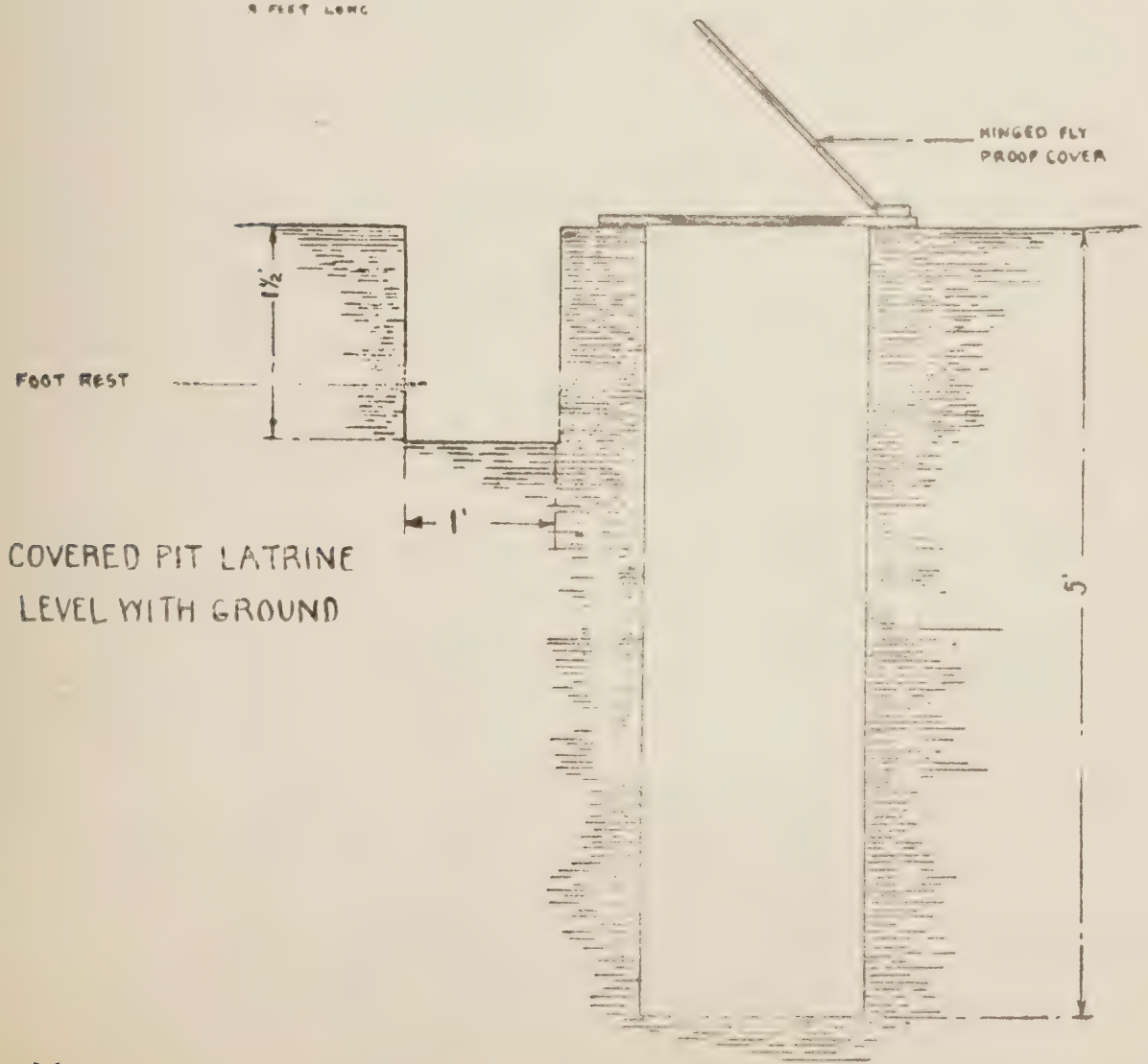


GARBAGE CAN WITH TOP CONVERTED INTO PORTABLE URINAL

FOR USE IN COMPANY STREET AT NIGHT



1-2-3
STRADDLE TRENCHES
1 FOOT WIDE
2 FEET DEEP
3 FEET LONG



COVERED PIT LATRINE
LEVEL WITH GROUND

PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY

OF DISEASE, HYGIENE AND SANITATION.

Lecture 26, MYIASIS--TYPES OF INJURY AND LIFE HISTORY

November 18, 1918 AND HABITS OF SPECIES CONCERNED.

F. C. Bishopp.

Myiasis is a term applied to the attack of living man or animals by fly larvae. The medical profession usually assigns specific names to the infestations according to their location - as dermal (in or under the skin), nasal (rose infestation), auricular or otomyiasis (ear attack), intestinal, etc. These names are not entirely satisfactory as often one form will develop into another or one species of larvae may be concerned in attacks in many different regions. And again several species may attack the same region but produce different types of injury, or the point of attack may vary with the stage of the larvae.

Any attempt to classify the different types of myiasis according to character or place of attack or species of fly concerned seems to have its objections and difficulties. For convenience in discussion I have attempted to divide the subject from the standpoint of method of attack into the following groups:

First, TISSUE DESTROYING FORMS, including those species which are ravenous feeders and destroy living tissues. For example the screw-worm (Chrysomyia macellaria). The species which are included in this group attack living animals secondarily, the main source of breeding being in dead animal matter.

Second, SUBDERMAL MIGRATORY FORMS which are parasitic in animals or man and occur during the major part of their lives beneath the skin. For example the ox warble "torcel" or Dermatobia in man, etc.

Third, LARVAE INFESTING THE INTESTINAL OR UROGENITAL TRACTS. These usually feed to a lesser or greater degree on food or excrementitious matter within the body. For example the larvae of the latrine flies of the genus Fannia and of certain flesh flies of the family Sarcophagidae. Infestations largely accidental except horse bots and related species in animals which are truly parasitic.

Fourth, FORMS INFESTING HEAD PASSAGES. True parasites of animals or man occurring in the head sinuses, throat or occasionally the eye. For example the sheep bot (Oestrus ovis and Cephalomyia spp.)

Fifth, BLOOD SUCKING SPECIES. Highly specialized forms with blood sucking as a normal habit, exclusively parasites of man or animals, such as the Congo floor maggot attacking man and larvae of the genus Protocalliphora attacking birds.

Myiasis is caused by many species in several families. The habits in regard to myiasis of the species of any single family vary widely as might be expected in groups which have become more or less specialized. For instance the family Oestridae which is the only family having all its species concerned in myiasis, has members which infest the stomach, others which develop in the nasal passages and still others which produce cutaneous myiasis. The family Muscidae also exhibits very diverse habits in this regard, some members being concerned in destructive myiasis, others in specialized dermal cases and still others are blood suckers.

Myiasis in animals is not generally considered in connection with human cases. There exists, however, a very intimate interrelationship; in fact the prevention of myiasis in man is largely dependent upon the control of the trouble in animals. Furthermore entomologists engaged in sanitary work must be prepared to handle insect attack on animals as well as man.

Owing to the need for careful determination of the exact species concerned in cases of myiasis, both for the immediate needs of the case and for the benefit of science, it is highly desirable that the larvae concerned be bred to adults whenever possible. Specific determination of the larvae, especially when small, is to say the least very difficult, but a few should be preserved in alcohol for record. Some suggestions as to breeding methods are apropos. There is no use endeavoring to rear Oestrids after extraction unless well matured. Most of the other forms may be reared by choosing suitable breeding media. The larvae from wounds will usually develop on beef. Care must be exercised to avoid contamination of material by other species, especially Sarcophigids which will drop larvae through screen wire onto meat or excrement. A double cage is best to avoid this; one of these should have a solid top. Good ventilation is important and sand slightly moist but not wet should be provided beneath the meat. The meat may be partially buried to retain moisture and reduce odor. It should be remembered that the larvae have a strong tendency to migrate when ready to pupate.

Returning to the discussion of the groups of myiasis above outlined:

TISSUE DESTROYING FORMS.

It should be said that most forms of larvae attacking man or animals may destroy body cells to some extent but not in the sense of the rapid tearing away of tissues as exhibited by species in this group. This is the most dangerous type of myiasis in man and one of the most important sources of loss among domestic animals. As previously pointed out the flies included in this group attack living animals as a secondary method of reproduction.

It should be stated most emphatically that cases of myiasis either in man or animals due to species in this group are more or less intimately associated with violations of the best sanitary principles. The

vast majority of cases of this type of myiasis occur in the warmer parts of the world. In the United States, as is well known, our principal source of trouble is due to the Muscoid fly (C. macellaria) commonly spoken of as the screw-worm. Several other species are concerned to a greater or less degree, among these should be mentioned the black blow fly (Phormia regina), the green bottle flies (Lucilia caesar and L. sericata), certain of the flesh flies (Sarcophaga spp.) and occasionally some of the hairy blow flies of the genera Cynomyia and Calliphora.

Fortunately from the standpoint of the sanitary entomologist the methods of control are in general very similar for all species owing to the similar habits and not vastly different life histories. All of the species are carrion breeders although the adult flies are attracted to various kinds of food, especially those with strong pungent odors as come from the cooking of cabbage or turnips. A few develop occasionally in human excrement, normally however, the decomposition of animal matter has the strongest attraction for them and in many regions it is with great difficulty that animals can be slaughtered without having the meat contaminated by their presence in large numbers. Garbage containing meat and bone will attract and breed them.

[illegible] AMERICA. The screw-worm fly occurs throughout the Unites States, but is of little importance as a pest except in the Southwest where in some sections it is a veritable scourge to the raisers of live stock. The life history of this species will serve as an illustration for this group of flies in the United States. The eggs are deposited on carrion, especially on animals which have died recently. These hatch in a few hours into maggots which enter the tissues rapidly and become mature in about six to twenty days. In living animals development seems to be rather more rapid. Pupation takes place in the soil from the surface to three or four inches deep and the flies emerge in from three to fourteen days. The total developmental period from attack to adult has been found to vary from nine to thirty-nine days. The activity of this species is confined to the warmer part of the year, usually from about April firsttto November first in the Southern States. The black blow fly (P. regina) on the other hand appears more resistant to cool weather and becomes most numerous in the southern region during early spring and late fall. This is also true to a large extent with the large hairy blow flies.

Infestations in animals occur on any portion of the body where there is broken skin or even on sound skin where blood spots occur. For the most part, however, the infestations follow mechanical injury or where ticks have been crushed on the host. In man practically any part of the body may be attacked, but the most common type of myiasis is nasal. This is especially true in Central and South America. Such infestations are usually associated with malignant catarrh or bleeding from the nose, and practically always with careless modes of living. The larvae enter the nose and penetrate the tissue rapidly producing extensive cellulitis and usually accompanied by considerable discharge.

If not detected for two days the injury is likely to be very serious. The frontal and ethnoid sinuses may be entered and the cartilage and even bone attacked. Often the tissues of the nose and beneath the eyes begin to collapse and sometimes excavation reaches to the surface, giving permanent disfiguration. This extensive destruction of tissues often results in septicemya or meningitis. Infestation of wounds on the battle field or even in hospitals is not at all infrequent, but such cases are much more easily treated than nasal infestations.

The black blow fly (P. regina) usually infests only old suppurating wounds. In live stock it is commonly found following dehorning and has also been proved to be a common source of wool infestation of sheep in the Southwest. In the latter case the soiled wool following lambing attracts flies and the maggots feed in this for some time but later may enter the sheep itself and cause its destruction.

The green bottle flies (L. sericata) and (L. caesar) which are commonly known as the wool maggots of the British Isles occur throughout the United States. They have been known to infest wounds in man and animals but the main source of trouble has been the infestation of soiled wool on sheep. The method of attack in wounds is similar to the screw-worms, but the tissue destruction is less rapid although this depends largely in either case upon the number of larvae present. They are more abundant in towns than in open country.

In South and Central America and the West Indies Chrysomyia macellaria abounds and gives similar troubles to those in the Unites States. In Brazil, Sarcophaga lambens and S. ryorhila have been reported by Neiva and De Faria to infest wounds. In Hawaii Calliphora dux has caused considerable loss by attacking soiled wool and scabs on sheep.

EUROPE. In Europe the principal trouble from myiasis occurs in southern Russia. A considerable number of cases occur in the Mediterranean region and some farther north in Austria and Germany. In Russia, according to Portschinsky, the vast majority of cases of this type are caused by the flesh fly (Wolfahrtia magnifica) which appears to have habits of attack on man and animals very similar to that of the screw-worm fly in America. Among the lower animals he speaks of its attack usually following wounds on the bodies of cattle, horses, pigs, dogs and poultry. The cases in man occur most commonly in the nose, ears and eyes. The injury is often serious, resulting in deafness, blindness or facial disfiguration and not infrequently in death. This fly deposits living larvae and infestations in man are usually the result of sleeping outdoors during the warm part of the day.

While this species is not commonly spoken of as a pest in western Europe, Bilgic reports considerable trouble from it in the western war theater, especially during 1915. It infested wounds and interfered with their proper treatment and was responsible for many infestations of the genitalia of cows in that region.

Next in importance comes the flesh fly (Sarcophaga carnaria). This form does not seem so prone to attack living animals as W. magnifica, but numerous cases of myiasis have been charged to it. Apparently it is found usually in old suppurating sores. These may occur on any part of animals or man. In the Petrograd district Lucilia caesar is responsible for some cases of myiasis while in Denmark, Holland and parts of Germany and France, L. sericata is concerned in the infestation of wounds. Calliphora erythrocephala, Musca domestica and Muscina stabulans are said to oviposit on corpses on the battle field soon after death but before putrefaction sets in.

The larvae of Anthomyia pluvialis L. has been reported as being concerned in auricular myiasis. Probably this species should be considered as a feeder on excreta rather than placed with tissue destroying forms.

AFRICA. Wolfahrtia magnifica is reported by Gough in Egypt as being taken from ulcers behind the ears and from orbits in the ophthalmic hospitals. In tropical Africa Lucilia argyrocephala commonly attacks mammals, man and birds. Members of the genus Pycnosoma, which has been included with Chrysomyia by some authors, cause myiasis in numerous cases. Pycnosoma regacephala and P. beggiana are frequently mentioned in literature in connection with cases of myiasis is cattle, horses, camels and other animals as well as man. P. rutorum Weid., P. marginale Weid., and P. chloropyga are also concerned. Sarcophagids have been recorded as infesting wounds, S. haemorrhoidalis and S. regularis being mentioned in particular.

ASIA. While there are numerous references to myiasis cases in Asia our knowledge of the species concerned is limited. Members of the genus Pycnosoma, particularly P. flaviceps Walker, are concerned with cases in India. This species and Lucilia serenissima Fabr. have been mentioned particularly as being troublesome by attacking cattle after outbreaks of foot-and-mouth disease. The cosmopolitan Lucilia caesar is responsible for some cases of myiasis. It is possible that they may be concerned with the spread of this disease in addition to the injury wrought by their burrowing into the tissues. Several members of of the Sarcophagidae have been reported as causing nasal myiasis of man in parts of India, but most of these have not been specifically determined. S. ruficornis seems to be among those most frequently concerned.

AUSTRALIA. While reports of destructive myiasis in man are comparatively few from Australia certain parts are subjected to veritabel plague of myiasis among sheep. The center of the region where this scourge occurs is in New South Wales where work for the commonwealth government has been carried on by Professor W.W. Froggatt for several years. Only a brief mention of the species concerned and the character of attack can be given. The loss is brought about through the blowing of the soiled wool, particularly around the vents of the ewes. The infestation if not promptly treated spreads forward in the wool resulting in a large loss in the clip and often the larvae gain entrance to the bodies of sheep

and produce their death. Even though penetration does not occur, the skin is acutely inflamed and gives rise to fever, loss of appetite and sometimes death. Froggat states that he has bred 1050 flies from the maggots in one pound of wool.

Froggatt holds that the blowing of wool is largely an acquired habit on the part of Australian flies as practically no cases of this kind were noted up to 1903 and 1904. He attributes the acquisition of this habit to the extended drought which destroyed large numbers of animals of all kinds and resulted in the production of myriads of flies. He thinks that during this period several species of flies acquired the habit of depositing in "smelly" wool. He also considers the more extensive breeding of heavy wooled sheep to be a contributory factor. It is certain that injury from blow flies has developed from an almost unnoticed trouble to a problem of first magnitude within the space of a few years. During the first few years of the acute trouble the small yellow house fly (Anastellorhina augur L), and the golden hair blow fly (Pollenia villosa) appeared to be the principal culprits. In 1913, when the work was taken up more extensively it was found that the "green and blue" sheep maggot fly (Pycnosoma rufifacies) was assuming first importance in connection with the infestation of sheep. The difference in apparent injuriousness is probably governed largely by the seasonal conditions as in the case of species in our own country, P. rufifacies apparently being concerned largely with cases of myiasis in summer and A. augura during the cool weather. The life histories of these flies do not differ materially from that of the screw-worm fly, the life cycle being completed in about two weeks under favorable conditions. Other species which have been bred from wool in Australia are Pycnosoma varipes, the Anthomyid, Ochyra nigra, Sarcophaga orifrons, and the cosmopolitan Lucilia sericata and L. caesar, and possibly L. tasmaniensis.

SUBDERMAL MIGRATORY SPECIES.

The species concerned in this form of myiasis are truly parasitic. In the cases of man they can not be considered as especially dangerous, but in animals they assume first rank as destructive parasites.

The type of myiasis produced bythese larvae is described under various names in medical literature but especially mentioned as creeping disease. This is owing to the movement of the larvae in the subcutaneous tissues. In the United States we have little concern for cases of myiasis in man produced by this group of flies as they are comparatively infrequent. The species concerned are Hypoderma, probably mostly lineatum and Gastrophilus, probably mostly intestinalis (equi). Unfortunately the larvae concerned have not been preserved usually and in very few cases have any larvae from man been reared to maturity.

The sanitary entomologist is little concerned with the Oestrids infesting cattle, but on account of their importance they are here briefly discussed. There are two species, H. lineatum and H. bovis concern-

ed, the former is the predominant form in the United States, especially in the southern three-fourths of the country, while the latter is more restricted to the northern tier of States, New England and Canada. The adults are known as heel flies and deposit on the hairs, principally on the legs of cattle. These eggs hatch in about four days and the larvae penetrate the skin at the point of attachment or in some instances may be taken in by licking. After several months spent in the body of the animal they appear during the late fall and winter months under the hide along the back, forming subcutaneous tumors. When full grown these grubs emerge from the host, drop to the ground and after about twenty-five to thirty-five days spent in the pupal stage produce flies which are ready to attack cattle the first warm days during spring.

Several cases have recently come under the observation of Mr. E. W. Laake and the writer of the occurrence of this species in the backs of horses. These are responsible for the production of lesions which practically render the use of the infested animals as saddle horses impossible.

There are a number of records of the occurrence of the young larvae of these flies in man, especially children. Attention is usually first called to them on account of pain, soreneessor itching in the region of the shoulders or face. The irritation is sometimes rather acute and its location moves with the burrowing of the larvae. Before becoming mature the grubs appear near the surface under the skin or beneath the mucous membranes of the mouth and can there be extracted with ease.

These infestations probably come about through the accidental depositions of eggs on the bodies or clothing of man, especially children. The possibility of this method of infestation is emphasized through the experience of Dr. Gläser who while studying ox warbles in Germany had a fly deposit an egg on his trousers which in due time hatched and the young larvae penetrated the skin of his leg. Later its presence in the oesophageal region was detected by an uncomfortable feeling. The larvae apparently passed up the oesophagus and later was extracted at the base of one of the lower molar teeth.

In instances where the Oestrid fly of the genus Gastrophilus attacks man the conditions surrounding the infestation as well as the exact identity of the larvaeare less well understood. It is supposed that the young larvae are in some way brought in contact with the mucous membranes of the lips, mouth or eyes and penetrate them, later appearing under the skin and moving about in a manner somewhat similar to Hypoderma. The life history of the species of this genus will be discussed under intestinal myiasis.

AMERICA. In America in addition to the Hypodermas we have among the lower mammals dermal myiasis produced by several different species of Oestrids in the genus Cuterebra. These are most commonly met with in rabbits, squirrels and certain field mice. Usually they appear to cause no serious injury except in the case of one form which is prone to at-

tack the testicles of squirrels and has been given the name of C. emasculator.

In South America a very interesting and more important form of myaisis in man occurs. This is produced by the Oestrid, Dermatobia hominis. This form appears to be normally the parasite of cattle, horses, donkeys and certain wild animals. It is reported as being a serious pest of cattle, in some cases causing the death of many calves, especially when the cutaneous tumors become infested with larvae of Chrysomyia.

The life history and habits of the species have not been fully eluidicated, although a number of important contributions have been made. It is generally concluded that the method by which it infests man is brought about in the following indirect but very interesting manner. The eggs of the fly are deposited either on the bodies of certain blood sucking insects, wspecially the mosquitoknown as Janthinosoma lutzi, or attached to leaves frequented by these insects whence they adhere to them. The eggs are attached vertically on the under side of the abdomen or on the legs. The embryos appear to remain dormant though fully developed within the egg and when the blood-sucking dipteron finds a host the heat of the animal or the blood taken up stimulates the larvae to break from the shell and penetrate the skin of the host. Dermal tumors are formed by the larvae, a well-marked hole opening to the outside as in the case of the ox warble. When the grubs become full grown they leave the host, drop to the ground and transform to adults. The period in the host ranges from two to six months. During this time there is more or less inflammation and sometimes acute pain. This form is widely distributed through tropical America.

In South America Dr. J.C. Nielson has reported the occurrence of the Muscid flies (Mydaea anomala and M. torquens) as producing subcutaneous tumors in various birds in parts of Argentina.

EUROPE. Several cases of dermal myiasis have been reported, especially from Russia. These are attributed to infestations of larvae of Hypoderma and Gastrophilus.

The infestation of reindeer in Lapland and farther south in Norway by larvae of the Oestrid fly (Oedemagena tarandi L.) should be mentioned. The infestations are almost analagous to those in cattle caused by Hypoderma. The eggs are laid on the hair during the spring and later the larvae appear in the submucous tissues of the back. As many as 300 have been reported as occurring in a single animal. This same species no doubt infests the reindeer in Alaska and Canada.

AFRICA. In Africa the outstanding form of dermal myiasis is produced by the Muscid fly (Cordylobia anthropophaga) commonly spoken of as the Tumbu fly. The larvae are known as "Ver du Cayor." These develop in the skin of man and various other hosts including dogs (probably the preferred host), cats , horses and other domestic and wild animals.

The attack is painful but not serious though no doubt when numerous specimens are present unpleasant symptoms follow. The life history of this form has not been entirely elucidated but it is generally believed that the eggs are deposited on the ground in places frequented by hosts and the larvae [illegible] penetrate directly through the skin. In some cases it appears that eggs have been deposited on clothing, especially if moist with perspiration. They appear in March and diminish until some time in September when they entirely dis appear. Experiments conducted by Roubaud indicate that the choice of host depends mainly on body temperature, the high temperature of hogs and fowls being fatal.

Cordylobia rodhaini is the cause of cutaneous myiasis in the forest regions of Africa. Man is an accidental host, the species normally infesting thin skinned wild mammals. According to Rodhain and Bequert who have given much attention to the biologies of this and related species, the eggs are deposited on the ground in the burrows frequented by the animals, the larvae hatch out and penetrate the skin when the hosts are lying upon them. The larvae develop within the host in twelve to fifteen days. The pupal stage which is passed in the ground, ranges from twenty-three to twenty-six days, the life cycle being about forty days. Another Muscid, genus Bengalia (especially B. depressa) causes cutaneous myiasis in man in Rhodesia and other parts of Africa. The eggs are deposited on the clothing or person of man and on the hair of animals.

Another interesting form is Neocuterebra squamosa which develops in the adipose tissues on the soles of the feet of the African elephant.

INTESTINAL AND UROGENITAL MYIASIS.

There is every reason to believe that myiasis of the intestinal tract and urogenital openings results largely from careless modes of living. The types of myiasis included in this group should not be confused with urogenital myiasis caused by Chrysomyia and related forms. A large percentage of these cases is purely accidental and there is no doubt that a great many larvae are ingested with food which never produce symptoms to attract attention to their presence. Several different families of flies have been recorded as causing intesitnal myiasis, one of the most common being the rat tail larvae of the family Syrphidae. Records of intesitnal myiasis due to Sarcophagidae are also numerous but it should be borne in mind especially with this fly that there are many opportunities for mistakes and with little doubt in many instances the larvae are not passed but are deposited in the excrement by flies which have the habit of visiting and depositing larvae almost instantly after defecation.

The whole group may be subdivided into those forms which are directly parasitic, such as horse bots, and others which are more or less accidental.

AMERICA. The importance of the horse bots in infesting equines is such that a brief discussion is necessary. The sanitary entomologist must necessarily concern himself with the protection of horses in the cavalry, artillery, etc. from the ravages of insects as well as to look after the welfare of the troops. In this country there are three species all of which are of considerable economic importance. These are the common horse bot, G. intestinalis DeG. (equi), the chin fly or throat bot fly G. nasalis L., and the nose fly G. haemorrhoidalis L. These three species are widely distributed throughout the world and will be met with as pests in any of the present war theaters. Certain other species are also present in European and Asiatic countries but these are of less importance.

The life history of the common bot fly is about as follows. The eggs are attached to the hairs of the host, mainly on the legs but frequently on other parts. These are ready to hatch in from nine to forty days. The larvae are removed from the eggs by the biting and licking of the host. They take up their abode in the stomach, remaining attached to the mucous coatings of the pyloric end of this organ until fully grown several months later. They then detach and pass out with the manure, pupate near the surface of the ground and produce the so-called bot flies three to six weeks later. The cycle is completed in about a year. The life history of the nosefly and throat bot are similar but differ especially in the method of oviposition. The former deposits its eggs which are nearly black on the very minute hairs around the lips. The young larvae gain access to the mouth and develop as in the common bot fly but before passing out they usually catch hold of the mucous membrane of the rectum and are often seen protruding from the anus a few days before dropping. The annoyance produced by the oviposition of this fly is very severe. The throat bot deposits its eggs mainly under the jaws and the larvae are often found in the duodenum and also attach in the stomach.

In addition to the annoyance produced at the time eggs are deposited heavy infestations in the stomach interfere with digestion and cases are recorded where the larvae cause death by stopping the pyloric opening. The irritation of bots, which may be present in numbers exceeding 1,000, must be detrimental to the host. The throat bot also attaches in the pharynx in its early stages and is accredited with causing the death of animals from this habit.

Cases of dermal myiasis in man attributable to these species have already been mentioned. European writers have also reported the occurrence of larvae of Gastrophilus in the eye of man.

Passing to those forms which are more or less accidental the Sarcophagidae demand first attention. Hasseman has reported a case in which an entire family was infested with the larvae of Sarcophaga haemorrhoidalis, the maggots being passed in considerable numbers during warm weather. Numerous other similar instances have occurred and in practically

every instance they are traceable to leaving foods exposed to flies between meals. Since the Sarcophagids deposit living larvae on meats etc. they may be easily overlooked.

Cases of intestinal myiasis due to Eristalis larvae are common in this country. A good summary of these cases has been made by Hall & Muir. It appears that they sometimes give rise to acute colicky pains but no serious symptoms. As is well known, the rat tail larvae are to be found in decaying vegetation and in water and the source of infestation must be through the swallowing of uncooked and poorly cleaned food such as watercress, lettuce and the drinking of unclean water. The following species have been recorded in this connection: Eristalis tenax, E. dimidiatus, E. arbustorum and Helophilus pendulus.

The cheese maggot or skipper is referred to in a number of instances as the cause of intestinal myiasis, often producing intense colic and this form has also been recorded from the nose. On account of the common habit of this fly of depositing its eggs in cheese and smoked meat it is no doubt often eaten in considerable numbers and the cases where it gives trouble must be comparatively few. This insect passes its complete life cycle in the foods mentioned above, usually attaining the adult stage in about three weeks. It is world wide in distribution.

Species of Muscina, especially M. stabulans, have been met with frequently in cases of intestinal myiasis, especially in Europe.

Mydaea vomiturationis is charged with a case of fatal intestinal myiasis.

Hydrotaea meteorica, which form is probably normally predaceous in the larval stage, has been found to produce intestinal myiasis.. Blood is sometimes passed accompanied with severe pain.

Larvae of the common house fly have been passed in living condition, sometimes preceded by pain. Most of these cases have been in infants and the larvae no doubt usually gain access through the anus. These cases usually result from improper care.

The cluster fly (Pollenia rudis) of the family Muscidae has been reported in a case of intestinal myiasis. It is difficult to see how this form could gain access to the human alimentary tract since it is normally found only as a parasite of earthworms.

The Anthomyid flies of the genus Fannia have been recorded as causing serious gastric disorders. Among the symptoms are abdominal pains, nausea and vomiting and sometimes vertigo, headache and bloody diarrhoea. Fannia canicularis L., commonly called the lesser horse fly, and F. scalaris, are widely distributed and breed in various decaying vegetable matter and excrement.

In the urogenital infesting group the above mentioned species of Fannia which are also known as the latrine flies figure most prominently. These species are rather strongly attracted to human excrement, especially urine. This habit is undoubtedly responsible for the infestations of the genitalia. Such infestations must certainly be attributed to the exposure of the genitals in sleep by drunken or careless persons or occasionally infants. Robineau-Desvoidy has reported a case in which an Oestrid larva was passed from the bladder by a woman. Kollar has reported the occurrence of a large number of larvae of the common house fly in the vagina of a diseased woman. Chevrel has brought together a number of records of cases of myiasis of the genitalia.

In certain parts of tropical America and the West Indies, India, Ceylon and the Malay States the small Phorid, Aphiochaeta ferruginea Brunetti has been found infesting the human intestinal canal in many instances. Brunetti states that specimens of this fly were sent to the Indian museum by Crombe with a statement that "eggs, grubs and flies were all voided together." This occurrence, together with observations made by Baker and reported by Austen, indicate that the flies are capable of living and depositing eggs in the human intestines. This is also substantiated by the fact that larvae of this fly may be passed with excrement for as long as a year with symptoms similar to those of beri beri. Other members of the family Phoridae have been found in human corpses buried for two or more years; living larvae, pupae and adult flies being found together. A. ferruginea breeds in excrement and often frequents various foods including fresh meat. It also breeds in carrion. Its small size enables it to pass through ordinary screen wire and thus increases its potentialities for producing disease.

EUROPE. Nearly all of the above mentioned forms are to be encountered in parts of Europe. In the Mediterranean countries one would expect to find a greater number of forms leading to these types of myiasis.

AFRICA. Several of the previously mentioned forms occur in Africa. The Oestrid larvae (Pharyngobolus africanus Br.) commonly attaches to the walls of the oesophagus of the African elephant, and an Oestrid of the genus Cobboldia (C. loxodontis Br. and C. chrisidiformis Rod. & Beq.) are found in the stomach of the African elephant, and C. elephanis Cobb. attacks the Indian elephant in a similar way. Species of Girostigma in the same family infests the stomach of the Rhinoceros. Anthomyia disgordiensis is said to be not infrequently passed from the intestines of man in Angola.

FORMS PRODUCING MYIASIS IN HEAD PASSAGES.

All of the species included in this group are normally parasitic on animals and infestation of man although not uncommon must be considered accidental. In the lower animals the attack of these larvae is often quite injurious though not usually fatal in itself. In man the principal injury sustained is in the effects on the eye when it happens to be attacked.

AMERICA. In the United States as well as in all parts of the world the sheep head maggot (Oestrus ovis L.) is the most important form in this group. The fly deposits living larvae on the nose of the sheep and the young maggot works upward through the nasal passage, later entering the head sinuses. The maggots are quite spiney and hence must produce much irritation. They appear to subsist upon the mucous secretions of the head cavity. Several months are passed in the host and the larvae drop out and pupate in protected places on the ground producing flies a few weeks later.

I know of no record of the attack of man by this species in the United States, but in other countries it frequently attacks the eyes, nose, mouth and ears. The fly deposits the larvae so quickly that there is little opportunity to protect ones'self. The most serious symptoms develop from infestation of the eye where larvae produce severe conjunctivitis and in some cases if not promptly removed cause the loss of sight.

In this country the Cervidae (deer, elk, etc.) are attacked by Oestrids of the genus Cephenomyia (C. pratti, phobifer and macrotis). The larvae of these flies are found in the head passages, pharynx and even in the lungs.

EUROPE. The sheep head bot has a wide distribution in Europe and is responsible for loss among sheep and infestation of man as above described.

Probably the most important species in this group is Rhinoestrus purpureus Br. which is a very common parasite of the horse in Russia, Hungary and Italy. This form is also responsible for cases of myiasis in the eyes of man, the attack apparently being similar to that of O. (Oestrus ovis). Horses are infested by the flies which deposit larvae in the nose or eyes. They are much annoyed by the deposition of the insect and the larvae give rise to fits and other symptoms mistaken for strangles sometimes result in death. The species is also known to attack the zebra. Cases of the occurrence of this species in the eyes of man have been reported from Jerusalem, and are not infrequent in southern Russia.

The reindeer in Europe are subject to the attack of Cephanomyia trompe L. in a way similar to the infestation of sheep. Nativig reports the finding of as many as 100 larvae in the nasal cavity and larynx of a young reindeer.

AFRICA. In Algiers, especially, O. ovis is very destructive to sheep and many cases have been reported by the Sergents and others of the infestation of man by this species. The horse head bot (R. purpureus occurs in the Egyptian region. The camels are infested by the Oestrid, Cephalomyia maculata Wied. (Cephalopsis titillator Clark).

Many species of Oestrids occur in the head passages of African animals. Rhinoestrus hippopotami Grunberg occurs in the skulls of hippopotami and apparently this species attacks hogs. The genera

Gedoelstia and Kirkoestrus each contain species which infest the head sinuses of African wild mammals.

BLOOD SUCKING FORMS,

This mode of attack is not generally considered myiasis but it seems to have a logical place in this discussion. All of the species having blood sucking habits developed among their larvae are to be found in the family Muscidae. Up to the present time there seems to be comparatively little importance attached to them although such forms as the Congo floor maggot may be responsible for the introduction of disease germs into man.

AMERICA. The only representatives of this group found in North America are Protocalliphora azurea and P. chrysorrhoea. The first mentioned species is found commonly in Europe where it was first recorded as feeding in the larval stage on nestlings of the sparrow and other birds. This same habit has been observed in the United States. The second form which is quite common in the nests of larks and other birds in the southwestern states appears to cause a definite dermal myiasis as the larvae are frequently found partially imbedded in the wings, legs and body tissues of the fledgelings. The fly (Mydaea picipes Macq.) is reported as infesting young birds in a similar way in Brazil.

EUROPE. Protocalliphora azurea above mentioned is quite common in the nests of birds in France and P. sordida has similar habits.

AFRICA. The form which is especially interesting and important in this group is the African floor maggot (Auchmerorvia leuteola). This fly appears to be very closely associated with man. The adults are found in the dwellings and about latrines in tropical and subtropical Africa. The eggs are deposited on the dry soil of the floors or native huts, especially under sleeping mats. The larvae come out at night and attack the sleepers, filling with blood in a very short time. The adult is also a blood sucker. The larval stage occupies about fifteen days and the pupal stage about eleven days. The larvae do not burrow into the tissues but simply attack the skin with the mouth hooks and suck the blood.

The related genus Choeromyia contains three or four species including Choeromyia and boueti which occasionally bite man but normally live in the burrows of such hairless animals as the wart hog and ant bear. The habits are similar to the floor maggot.

Certain birds are attacked by the larvae of Passeromyia heterochaeta Vill. in a way similar to that reported for Protocalliphora. This form occurs in central Africa and also in China.

be attacked.

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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY

OF DISEASE, HYGIENE AND SANITATION.

Lecture 27. MYIASIS -- ITS PREVENTION AND TREATMENT.

November 18, 1918. E.C. Bishopp.

In a preceding lecture the habits and biologies of the various species concerned in myiasis in man and animals have been briefly outlined. An accurate knowledge of the species concerned and a good general idea of its biology and habits are essential to the proper handling of myiasis, especially when the cases are numerous.

In discussing control of the flies concerned and the treatment of cases the same general grouping as made in the previous lecture will be followed. Where various species of blow flies and related forms are numerous immediate steps should be taken to determine the source of supply and energetic steps applied to prevent it without waiting for the appearance of cases of myiasis in man or animals.

Tissue-Destroying forms.

PREVENTION OF BREEDING. Since practically all species concerned in the production of this form of myiasis develop within decaying animal matter, first attention must be given to this point.

Burning of carcasses. The carcasses of large animals are sources of tremendous numbers of flies. We have estimated that over a million specimens may be produced in the body of one cow. Nothing is as satisfactory as complete destruction of carcasses by burning. This not only prevents fly breeding but reduces the chances of the propagation of such diseases as black-leg, anthrax and tuberculosis. Carcass burning can be carried out under practically any condition with which the sanitary entomologist will have to deal and the process is by no means difficult nor expensive. Various methods have been advocated but we have found nothing equal to the following: Dig a trench about eighteen inches wide, twelve or fourteen inches deep and equal to the length of the carcass to be burned. This trench should be dug parallel with the prevailing wind and along the back of the carcasses, fill the trench with wood and then turn the animal over on top of it. Start the fire in the windward end of the trench and no further attention is necessary for several hours when the extremities may be piled in the center to complete burning. The placing of wood on top of the carcass and addition of wood after the fire has started are unnecessary. About one-quarter of a cord of wood is adequate, and where wood is scarce burning may be accomplished by using crude oil. Of course a few sticks of wood beneath the carcass will help hold the heat but this is not necessary. Ten to twenty-five gallons of crude petroleum are sufficient. The odor from carcass burning is not usually objectionable, especially if the animal is destroyed soon after death.

Carcass Burial. Burial is generally unsatisfactory, especially if bodies are well infested with maggots. We have found that at least twenty-four inches of finely packed earth are necessary to prevent their escape. The free use of quicklime on the body after it has been placed in the grave helps to destroy the maggots and reduce chances of disease spread. We have not yet undertaken experiments with the treatment of carcasses for burial with creosote oil, but judging by results obtained from treating those on the surface this should be a good method of destroying larvae, reducing odor and killing disease organisms.

Treating with chemicals. Nearly all maggots of this class of flies are exceptionally resistant to the action of chemicals. We have found some to survive submergence in very destructive insecticides. Foreman and Graham-Smith working in England have found that creosote oil, which is one of the higher distillates from coal tar, is quite efficacious in the treatment of carcasses. Two things are accomplished - the majority of the larvae are actually hit by the spray and destroyed and decomposition is practically stopped with corresponding reduction in odor. In recent experiments conducted at the Dallas laboratory we have found that several American makes of creosote oil are excellent for this purpose. Small carcasses thoroughly sprayed before infestation takes place will remain free from infestation, the flies being repelled by the substance and odor practically prevented. The carcass usually shrinks and assumes a mummified condition. Such creosote oils are manufactured by a number of concerns and is usually sold at prices ranging from sixty-five cents to one dollar per gallon, according to the per cent. of coal tar acids contained. Rather high percentage of these ingredients (at least 12%) is best.

Since direct sunlight is a powerful destructive agent in the semi-arid and arid regions, if burning cannot be accomplished the carcasses should be left in the most exposed place possible - not in a gully under shade as is usual. This will often result in about 85% control.

Disposition of Garbage. The question of garbage disposal has been discussed briefly in another lecture. Nearly all garbage is attractive to blow flies as well as other forms and the bone and meat scraps become infested. Where incineration is practicable it is most desirable. When fed to hogs the bones should be picked out and placed in a screened compartment or treated with borax or creosote oil.

DESTRUCTION OF FLIES. In general the destruction of flies should be considered as secondary to the elimination of breeding places, but under certain conditions this method of attack has its place.

Traps. Various types of traps have been devised for destruction of flies but a careful comparison of many different forms in experiments carried out at the Dallas Laboratory shows that there is much difference in their efficiency and also that some minor changes in the construction of a trap may greatly improve the size of the catch. As a result of

these experiments the fly trap described in Farmer's Bulletin No. 734 is being recommended by the Bureau. This trap appears to be the best all round form for catching both houseflies and blowflies. Of course the frame work of the trap need not be made of hoops and barrel heads as suggested in that bulletin although those prove very satisfactory. The essential principles are to have the high cone, comparatively large opening at the top of the cone, screened area over the cone to admit light from above, screened sides so as not to cast shadow around the bait, and legs about one inch high. The tent traps are not as efficient as the cone traps and this inefficiency is especially marked in some makes of traps as are now being furnished the army which are built with a broad bottom on either side of the tent. This repels the flies to such an extent as to make the traps almost worthless. For blow flies this darkened area is not so objectionable as for the house fly. While not strictly a trap the method of covering carcasses with burlap as recently suggested by Froggatt in Australia may be of value. Four stakes are driven into the ground around the carcass, and the tops of these are connected with a heavy wire. The canopy is then put over the stakes, brought to the ground and dirt piled on the edges. When the flies emerge they are imprisoned and soon die. If the canopy is not sufficiently large there is danger of many escaping through the migratory habit of the larvae.

Kind of bait to use. This point has been discussed in a previous lecture. Good baits and proper attention to killing and rebaiting are essential to best results.

Poisons. It is possible to destroy large numbers of flies by means of poisoned baits. Arsenic solution made by boiling arsenic in water mixed with defibrinated blood, gut slime or some other attractive bait will kill large numbers. This bait may be placed in covered containers to prevent dilution by rain. Cobalt may be substituted for arsenic. When carcasses can not be burned Froggatt has advocated slashing them and spraying with arsenic solution. This poisons large numbers of flies and maggots and reduces the attractiveness of the carcass; so much so, in fact, that birds and animals will not touch it.

Avoidance of Attack on Man. To prevent fly attack it is necessary to have wounds promptly and properly dressed. Man should avoid exposure by sleeping in the open during hot weather, especially if there is any trouble from catarrh or nose bleeding. Properly screened hospitals are of much importance and individual blow flies found within should be promptly killed.

Avoidance of attack to animals. In preventing screw-worm attack in cattle and other live stock there are several important points to be considered. Breeding should be done so as to have calves come during fall, winter or early spring months. Branding and surgical operations should also be done out of screw-worm season. Care should be taken to avoid mechanical injury to stock. As the screw-worm flies

are worst in brushy pastures clearing out all underbrush will be found beneficial. Since many cases develop from infestation of ticks and mange, the destruction of ticks and mange mites on animals is important. Care should be exercised to guard against extensive saddle or harness sores on army animals.

Methods of preventing blowing of wool on sheep hardly need to be discussed fully here. Shearing early in the spring, avoiding the soiling of wool, raising hornless breeds and the crutching, that is clipping the wool at the vent and behind the hind legs greatly reduces infestation.

TREATMENT OF INFESTATIONS IN MAN. Nasal myiasis is the most difficult to handle. The larvae should be removed mechanically as far as possible. A number of different treatments have been resorted to, the administration of chloroform in the nose being the most used. After all larvae have been taken away it is usually necessary to exercise care to prevent breaking of blood vessels which are frequently greatly exposed by destruction of the surrounding flesh. In most wounds the larvae are quite easily removed. Of course the details of the care of the patient is a matter to be determined by the physician in charge.

TREATMENT OF WOUNDS IN ANIMALS. Chloroform is the most generally used of all reagents and is usually satisfactory. The chloroform is poured directly into the holes and the wounds closed up. This benumbs the larvae so that they can be taken out with a forceps. Carbon tetrachloride is also satisfactory for this use and considerably cheaper. After the larvae have been taken out antiseptic astringent dressing should be applied and pine tar or pine oil and vaseline applied to the outside to repel flies.

Sub-Dermal Migratory Species.

The reduction of the number of oxwarbles in cattle is important from the standpoint of the raiser as well as to lessen the chances of infestation of man and horses. The most feasible method yet devised consists in the squeezing out of the larvae from the backs of the animals after they have formed the subcutaneous tumors. This should be done at intervals of about three weeks, all animals being gone over carefully. The period for beginning extraction varies according to latitude from October 15th to March 1st.

The question of controlling Dermatobia hominis in tropical America, and also its African analogue, Cordylobia anthropophaga, has not been sufficiently worked out to make satisfactory recommendations. No doubt where live stock are under control systematic extraction will reduce the number of these both in animals and man. When humans become infested it is usually advisable to allow the larvae to become stationary and then remove it through the hole in the skin. It may be necessary to enlarge the hole to get it out most easily. In the

case of the American forms the bite from various blood-sucking diptera should be prevented as far as possible. Having the body wall protected with clothing will also probably reduce injury from both of these species. On account of the probability that some of the African parasites of this class deposit eggs on exposed clothing, especially if wet with perspiration, this should be guarded against.

E
SPECIES CAUSING INTSTINAL AND UROGENITAL MYIASIS.

CONTROL OF TRULY PARASITIC SPECIES, in Animals. There are three principal methods of attack against the bots of horses. The destruction of eggs will accomplish much good in the case of Gastrophilus intestinalis and is applicable to some extent to G. nasalis, but apparently can not be practiced in G. haemorrhoidalis. Dove has found that the common practice of washing the legs of horses with kerosene oil has but little beneficial effect. The creosote derivatives containing about two per cent. phenols destroyed the eggs readily. A Miscible creosote compound reduced with water to this strength and applied with a rag or brush at the time the horses are groomed will destroy practically all eggs present. Such treatment repeated weekly should accomplish almost complete control. In this way army horses and mules may be kept practically free from infestation. Of course the grooming itself will tend to hatch eggs and get rid of larvae. Clipping of the hair on the legs has also been recommended but is not entirely satisfactory. Dove has experimented with certain halter devices for the protection of horses in pastures and also with various types of guards to be used on horses in harness to prevent the attack of the nose fly. In the first case he used a halter from which is suspended a box-like arrangement that covers the nose when the horse has its head up, but permits of grazing and drinking. A canvas extends back under the jaw to prevent deposition of eggs by the throat bot, and of course the covering of the mouth prevents the ingestion of eggs of the common bot. The main difficulty has been the production of a durable device of this kind. The nose fly attack is best prevented by a rectangular piece of belting being suspended from the bit rings immediately below the lips.

The internal treatment of infested animals with carbon disulphide has been found to be very effective if properly done. Three 3-dram doses at hourly intervals are given in capsules succeeding a period of starvation and followed by a purgative.

Prevention of Attack in Man. The reduction of the number of bots by treatment of the lower animals will greatly reduce the chances of infestation in man. Care should be exercised not to ingest eggs or larvae when infested horses are being clipped or groomed.

PREVENTION OF ATTACK BY OTHER FORMS. This group includes those species accidentally infesting man such as the Miscids, Fannia, Musca domestica, Muscina spp. and Syrphus flies.

Destruction of Breeding Places. Since most of these forms are

breeders in excrementitious matter and decaying vegetation the proper care of manure of all kind is important. This has been disucssed in other lectures. Since some of the species, especially the Fannias, breed in accumulations of decaying vegetation such as straw, roots, etc. these should receive attention, especially when close to camps.

Destruction of Flies. The use of traps is effective against most of the species concerned except the small Phorids and Syrphids which are not inclined to enter traps baited with usual baits. Poisonsbaits and fly paper will also destroy some species other than the house fly.

Food and Water. The careful preparation of uncooked food such as cress, lettuce, etc. is important. No doubt many of the cases of infestation by Fannia and Eristalis have been due to the eating of improperly washed foods of this kind. Drinking promiscuously from streams and pools should not be permitted. During the present war the provision of a good water supply for the men has received first consideration. Of course this is important to prevent infestation with various disease organisms. Distillation, filtration and chlorination are the preferred methods of producing pure water. Where it is essential that water must be taken from streams care should be exercisednot to drink near vegetation.

Use of Screens. Proper screening of houses will do much to protect foods after preparation from infestation although some of the small forms cannot be kept out in this way. A coarser mesh than 16 perinch should not be used. The use of screened toilets of course can not be too strongly emphasized.

Cleanliness and Careful Habits. Many infestations of the digestive system and genitalia could be avoided by not sleeping in unscreened places in an exposed condition. Prompt attention to infants is important.

SPECIES INFESTING HEAD PASSAGES.

These parasitic forms are very difficult to control and no very satisfactory control measures have been devised. Nearly all of the recommendations made are of little value. Some of these consist of the use of repellents in the case of sheep. Pine tar is most frequently used a and this is applied by the sheep themselves. Holes in logs are used for salting and the sides are smeared with the tar. The provision of plowed furrows where the sheep can protect their noses probably gives some relief. For very valuable animals screened pens are no doubt warranted, the animals being placed in these during the portion of the day when the flies are most active. There seems to be considerable in effect of attacks on breeds. Attempts to remove the larvae from the nose by causing sneezing or with fumigants are/likely to drive the larvae deeply into the head than to remove them. Trephining the skull and removing the larvae in that way may give some relief but is usually not advisable as other infestations are likely to follow and all

the grubs can not be reached. Destruction of adults has been advocated and is especially applicable to plains areas as in such places flies are inclined to congregate on any objects which extend well above the ground. The flies assemble on such objects and remain there except during the warmer part of the day and many can be killed.

Many of the control measures suggested for the control of the sheep bot can be used against the horse infesting species, Rhinoestrus purpureus. It might also be possible to utilize muzzles similar to those advocated for the horse bots to protect against infestations from this species.

Infestations in Man. Infestations of man are so infrequent that preventive measures need receive little attention. Where such infestations either by the sheep head maggot or horse head maggots are common the use of nets on the hats similar to those used by apiarists would give protection. Medical attention should be given promptly for larvae removal, especially if in the eye.

BLOOD SUCKING SPECIES.

In Birds. Since these dipterous parasites are often highly injurious to birds and especially to certain beneficial varieties control measures should be considered although nothing has been done along this line. In the Southwest it is stated that the mortality among birds is very high owing to these parasites.

Possibly trapping of the adults in connection with the control of other destructive species would be beneficial

In Man. The Congo floor maggot is the only species in this group requiring special attention. The use of beds instead of sleeping mats laid directly on the floor will give immediate relief. Where beds are not at hand hammocks may be used. The avoidance of sleeping in huts is advisable. Thoroughly cleansing and disinfection of the floor should destroy many maggots and the elimination of cracks in the dirt will check their breeding. Where sleeping mats are used by the natives they should be sunned and aired frequently. It is said that the maggots are carried from one hut to another in these mats so that moving the place of abode does not eliminate the trouble.

PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

Lecture 28, November 18, 1918.

THE BED BUG AND OTHER BLOOD SUCKING BUGS:-- DISEASES TRANSMITTED, BIOLOGY AND CONTROL.

W. D. Pierce.

Probably no species of blood-sucking insect is better known throughout all the world than the bed bug Cimex lectularius. This species and its congener, C. hemipterus (rotundatus) live in the beds of man and suck human blood. There are a number of related species, among which C. boueti in French Guinea is also said to suck the blood of man. The other species are bird parasites.

On account of the habit of the bed bug of sucking the blood of man, but hiding by day in houses and vehicles, this species has many opportunities of transmitting diseases, provided that its methods of life conform with the requirements of the disease organisms.

Any disease which should be shown to be spread entirely by the bed bug will undoubtedly have a localized distribution, and is very likely to be confined to certain buildings or certain groups of buildings, but on the other hand may spread long distances by travellers carrying the bugs in suit cases and on their clothes. It will never be possible for a bed-bug-spread disease to spread rapidly like a fly-borne or mosquito-borne disease. There is some very interesting literature on the possible disease transmitting role of bed bugs and this has been briefed and arranged below in the same manner that the discussions of diseases transmitted by other insects have been arranged in preceding lectures.

PLANT KINGDOM.

THALLOPHYTA: FUNGI: BACTERIACEAE.

Bacillus leprae Hanson the cause of LEPROSY has been considerably experimented upon with a view to determining the possibility of bed-bug transmission. Carmichael, in 1899, suggested the possible connection between bed bugs and leprosy. Long, in 1911, conducted experiments. He allowed two bed bugs to bite lepers in the neighborhood of leprous nodules and then examined the alimentary canal of the bugs and found them to contain the bacilli. He cites in one of his papers a case of a certain man who slept in a hut formerly occupied by a leper. He was bitten by bugs while sleeping there and later developed the disease. Skelton & Parham think transmission by bedbugs in Zanzibar to be improbable. Thomson has conducted a few experiments with this organism and Smith, Lynch and Rivas have also published an article on the transmissibility of the

leper bacillus by the bed bug.

Bacillus pestis Kitasato, the cause of BUBONIC PLAGUE, has been experimented on by a number of authors to determine the possibility of transmission by bed bugs. Vubitski conducted certain experiments which are reviewed by Manning. Cornwall and Menon have also written on the possibility of transmission of plague by bed bugs.

Bacillus typhosus Eberth, cause of TYPHOID FEVER may possibly be transmitted by the bed bug, according to Riggs.

DISEASES OF UNKNOWN ORIGIN.

POLIOMYELITIS or INFANTILE PARALYSIS has been suspected by various authors of being insect transmitted. Manning has made a contribution to the study of the possible agency of the bed bug in the transmission of this disease and claims that the bed bug fulfils the necessary requirements as a carrier of this disease.

ANIMAL KINGDOM.

PROTOZOA.
MASTIGOPHORA: BINUCLEATA: TRYPANOSOMIDAE.

Trypanosoma brucei Plimmer and Bradford, the cause of NAGANA of animals, and probably identical with the causative organism of SLEEPING SICKNESS, was experimentally transmitted, according to Sangiorgi, to white mice by the bite of Cimex lectularius, This organism is normally transmitted by tsetse flies and horse flies.

Trypahosoma cruzi Chagas, the cause of CHAGAS FEVER, a disease of man in South America, is carried by sucking bugs. The disease has its reservoir in the armadillo and related animals. Chagas and Brumpt have proven that the natural invertebrate hosts are the kissing bugs Triatoma megista, T. sordida, T. geniculata and T. chagasi and, undoubtedly also Rhodnius prolixus. Gonzalez-Lugo has obtained experimental transmission with the last named bug and Brumpt has proven it a durable host. Brumpt has also demonstrated development in the bed bugs Cimex lecutlarius, C. boueti and C. hemipterus.

There are two types of reproduction of the organism in the insects. In the sexual method, about six hours after ingestion of blood the kinetonucleus moves close to the trophonucleus with which it possibly blends; the flagellum and undulating membrane are now usually lost, but some forms retain the flagellum. The parasite becomes rounded and multiplies repeatedly by division. After this has ceased it becomes pear-shaped, develops a flagellum and becomes a crithidial form and then passes into the cylindrical portion of the intestine where it can be seen in about 25 hours after the ingestion of blood. The final stage is a small trypaniform type, long and slim with band-like trophonucleus and large kinetonucleus. This form is found in the hind gut in the body cavity and in the salivary glands and is the form by which the parasite is transmit-

ted to a new vertebrate host. The development in the bug requires at least eight days for its completion.

The asexual method of reproduction is a constant process and is a simple multiplication, giving rise to the crithidial forms which are found principally in the hind gut.

Originally the disease was supposed to be transmitted by the sucking of blood by insects. Brumpt declares that transmission is exclusively by dejections. As Rhodnius prolixus passes its dejections immediately after removing its beak, while the Triatoma species do not pass dejections during their repast, Brumpt thinks it likely that Rhodnius is a more potent transmitter, in view of the fact that dejections are infective. In this connection, the bed bug has a very interesting habit which bears upon the possibility of its transmitting the disease. Patton and Cragg have pointed out that it defecates immediately after a feed, but unlike the majority of blood-sucking insects, does not pass out red blood, but only the remains of the last meal, a semi-solid sticky material. This black fluid is passed out just after the proboscis is withdrawn and the bug has a very characteristic habit of turning around and moving backwards in such a way that the excreta fall in the neighborhood of the wound made by the proboscis. Blacklock has studied the multiplication and infectivity of T. cruzi in Cimex lectularius, and concludes that the organism is capable of living and multiplying in the bed bug for long periods. The parasites found in the bed bug are infective on inoculation as early as 21 hours and as late as 77 days from the infecting feed. Transmission of the disease to healthy animals by feeding an infected bug on them is of very rare occurrence. It was only once observed in the course of these experiments. In the light of Brumpt's work, we can now see that feeding experiments were almost naturally to be expected not to succeed, as the transmission of the disease is apparently only by contamination through scratching in or inoculation of infected feces.

Trypanosoma duttoni Thiroux, an organism usually found in mice, has been shown by Brumpt to be capable of developing in Cimex lectularius. It is usually parasitic in fleas and is transmitted to the mice by their licking up the feces of the fleas or the fleas themselves. It is probably infective by means of bed bugs in the same manner.

Trypanosoma equinum Voges, the cause of MAL DE CADERAS, a South American disease of horses, of which the wild animal reservoir is Probably the capybara, is probably transmitted by the kissing bug, Triatoma infestans, but Sangiorgi succeeded in transmitting it to white mice by the bite of Cimex lectularius.

Trypanosoma lewisi, Kent. the cause of RAT TRYPANOSOMIASIS, is usually carried by fleas, but Brumpt (1913a) finds that it can complete its cyclical development in Cimex lectularius and he infected a rat with an inoculation of the rectal contents of a bug after six days and also after 38 days.

Trypanosoma vespertilionis Battaglia, the cause of a BAT TRYPANOSOMIASIS is transmitted by the bat bed bug, Cimex pipistrelli, according to Pringault.

MASTIGOPHORA: BINUCLEATA: LEPTOMONIDAE.

LEISMANIA species, the cause of non-ulcerating Oriental sore, passes part of its life cycle in the bug Erthesina fullo, according to Carter .

Leishmania donovani Laveran & Mesnil, the cause of INDIAN KALA AZAR has been thought by many to be transmitted by insects. There is considerable conflicting evidence on the subject, a greater part of which is reviewed very thoroughly by Wenyon. Patton has demonstrated the development of the organism in the bed bugs Cimex hemipterus (rotundatus) and C. lectularius in India. Cornell and La Frenais fed Cimex hemipterus on citrated rabbit blood containing this organism through a membrane and obtained infection of the bugs and development of the parasites for a period of at least 29 days. Cornwall and Menon having shown in previous papers that the bed-bug cannot regurgitate the contents of its stomach in the act of feeding and therefore cannot transmit kala azar or oriental sore by its bite, and being unable to find evidence of any intracellular stage of the parasite in the bug, turned their attention to the contents of the rectum. No one has been able to demonstrate the presence of any resistant stage in the feces of the bugs, although these authors have found active flagellates, and occasionally rounded forms, as far down as the lower intestines of the infected bugs, in a fairly large proportion of those examined. They failed to find any form which could suggest an extra-corporeal resistant stage. They have found active flagellates in the stomach contents of the bugs for 29 days.

The life cycle in Cimex hemipterus and C. lectularius has been demonstrated by Patton. The parasites are ingested by the bug enclosed in the large cells or leucocytes, and develop into fully flagellated forms without reference to the temperature of the external air. The size increases from 4 to 7 micra and vacuolation of the cytoplasm occurs on or after the second day. The single parasite may proceed directly to flagellation by the appearance of an area stained bright pink by giemsa, solution and called the flagellar vacuole. This vacuole which has a dark center, rapidly increases in size up to 1 to 3 micra, and passing to the surface, sends out a pink brush, which forms the flagellum by merely growing longer. The flagellate form has a dark blue, granular cytoplasm with a circular trophonucleus, which stains deeply in the center; and a kinetonucleus lying across the long diameter, and situated near the trophonucleus, and possesses a long flagellum consisting of a number of filaments adhering closely together, inserted into a pale area near the kinetonucleus. These parasites may divide into two equal flagellate forms, and apparently may go on dividing for some time. Instead of proceeding directly to flagellation, the parasite may show a division of its nuclei into two, with the formation of two flagella, and then division into two flagellate parasites, or the nuclei may multiply without division of the cytoplasm, so that forms containing four to eight nuclei

may be together, which eventually break up into separate flagellate forms. If the bug feeds on blood before the development is completed the flagellates are destroyed. Development is completed in ten to twelve days after a single feed.

Cornwall and La Frenais describe a thick tailed form in the bug after the 20th day. Cornwall and Menon states that the flagellate form thrives only at temperatures from 16° to 26° C, (61° - 79° F.) and is therefore unfitted to exist in the human body. This is further evidence that the flagellate is a typical insect form. They have failed to find a postflagellate cystic form in the stomach of the bug.

Transmission by insects has not been demonstrated although there is considerable evidence that it cannot be transmitted by the bite of the bed bug in which the organism normally flagellates. Cornwall and Menon claim that there are only two possible means of transmission left; rupture of a bug containing flagellates in the neighborhood of a puncture or abrasion, and passage of cystic forms in the feces, and there is no direct evidence for either. They lean to the rupture theory because it seems to account for the peculiar distribution of kala azar. It is comparatively rare and often localized in certain dwellings. The bug does not live on the person, but in buildings and furniture. It does not generally crawl over the skin when feeding, but attacks exposed parts from a fairly safe position. It must therefore be a comparatively rare event for a bug to be ruptured on the skin of its occasional host. They may be transported from place to place in furniture and clothing, and may go from house to house in search of food. The bug is also more or less localized. As the bug would be sacrificed in the act of transmission, it is clear that a human reservoir of the disease must be at hand if the bugs in a building are to remain dangerous. Knowles suggests the possibility of hereditary transmission in the bed bug or intestinal worms.

Leishmania tropica Wright, the cause of ORIENTAL SORE is also thought to be transmitted by insects. Wenyon found that the bed bug C. lectularius could take up the parasites and that developmental stages were demonstrable in its gut. Pattor (1912) obtained development of the parasite into flagellate forms in Cimex hemipterus at low temperature (22- 25° C.) and produces considerable evidence in favor of these species as the natural carrier.

MASTIGOPHORA: SPIROCHAETACEA:SPIROCHAETIDAE.

Spirochaudinnia berbera Sergent and Foley, the cause of NORTH AFRICAN RELAPSING FEVER, is spread by the body louse, Sergent and Foley have obtained negative results with Cimex lectularius.

Spirochaudinnia duttoni Novy and Knapp, the cause of TROPICAL AFRICAN RELAPSING FEVER is normally spread by ticks. Breinl, Kinghorn, & Todd in 1906 and Nuttall in 1907, were unsuccessful with transmission experiments with Cimex lectularius.

Spiroschaudinnia recurrentis Lebert, the cause of EUROPEAN RELAPSING FEVER is normally transmitted probably by the body louse. Nuttall, in 1907, experimented with the Russian strain of this disease and succeeded in transmitting relapsing fever, in one experiment, to a mouse by the bite of Cimex lectularius. He found that usually the spirochaetes were digested by the bugs, the time depending on the temperature. Flügge in 1897, infected monkeys with the contents of bugs, removed 24 hours after they had fed on relapsing fever blood. Karlinski and also Schaudinn observed the survival of spirochaetes in two bugs for 30 days or more. Various authors have failed to transmit spirochaetes by bugs, but it is probable that these failures were because they attempted to transmit by means of the bite rather than by crushing or scratching in the contents of a bug or its feces. Tictin, however, while suggesting that the bed bugs might transmit the disease by their bite, also suggested that it might be by their being crushed and the contents entering the skin through excoriationssdue to scratching.

In summary we may draw the conclusion that probably all disease organisms which are capable of passing part of their cycle in the bed bug will be found to be transmitted through the scratching in of the feces of the bug, or by the rupturing of a bug while in the act of feeding, or over an excoriation of the skin. It is quite possible that any organism which the bug may take up from the blood and which in like manner is infective to the blood, can be transmitted under favorable conditions in this manner.

There is most certainly a very promising field for research in the working out of the possibilities of disease transmission by blood sucking bugs.

LIFE HISTORY NOTES.

This lecture deals primarily with the bed bugs of the genus Cimex, family Cimicidae, but also contains mention of the false bed bugs, or kissing bugs of the genus Triatoma (Conorhinus), family Reduviidae.

The best discussion in English, with illustrations, of the genus Triatoma (Conorhinus) is given by Patton and Cragg. These bugs live on human and mammalian blood. The egg of Triatoma rubrofasciatus of India is rounded at one end and flattened at the other, which forms a kind of operculum. It measures 2 mm. by 1 mm. The incubation period varies from 20 to 30 days. The development is similar to that of all winged Reduviids, each stage showing more developed wing pads, until the fully winged adult stage is reached. The development requires several months from eggs to adult.

T. megistus of South America is almost entirely a domestic insect. The adults enter inhabited houses, but never those which have been abandoned. In old houses they are to be found in cracks and holes in the walls, where they lay their eggs. They early stages, which are wingless, crawl out of their resting places in the walls as soon as the lights are

put out and make their way to the beds of the occupants of the house. The adults behave in the same manner, but as they are powerful fliers they can reach people who sleep in hammocks. The bite is said to be painless and to leave no mark; this is quite unlike the bite of Triatoma rubrofasciatus, which in the case of some people leaves a distinct mark for weeks. The eggs of T. megistus are laid in batches of from 8 to 12, and as many as 45 such batches may be laid. They hatch in from 25 to 40 days. A generation requires about 324 days.

Triatoma sanguisuga is a native of the United States and is called the Texas bed bug, or the "blood-sucking cone nose." It comes into the houses, and sucks the blood of man. It is also found in chicken houses and horse stalls, but its normal food is supposed to be the body juices of other insects, including the bed bug.

A number of other species are recorded as causing severe bites on man.

The bed bugs Cimex lectularius, C. hemipterus (rotundatus), and C. boueti attack man, while C. hirundinis attacks the swallow, C. columbarius the pigeon, and C. pipistrelli the bat. The first named is cosmopolitan, the second tropical and subtropical, the third South American. The first two are essentially domestic species. During the day time these species hide in cracks and crevices in the beds, furniture and walls of bedrooms. They usually feed at night, but will not uncommonly feed in the daytime if they can do so without detection. The most characteristic features of the bed bug is the very distinct and disagreeable odor which it exhales. The absence of wings in the bed bug is of great advantage in control work, as it confines its range to those points it can reach in its roaming. The eggs are white, oval objects having a little projection run around one edge and may be found in batches of from 6 to 50 in cracks and crevices where the parent bugs go for concealment. A single female may lay as many as 190 eggs. The eggs hatch in a week or ten days in warm weather, but require a considerably longer time in cold weather, The young are yellowish white at first but in succeeding molts become darker and darker brown. There is very little important difference in the appearance of nymphal and adult stages. There are five molts covering varying lengths of seven to eleven or more weeks. The bed bug is capable of living for long periods without food. Normally fed bugs may live almost a year, and partly grown specimens have been kept 60 days without food. The bite of the bed bug is very poisonous to some persons, and their presence is sufficient to cause uneasiness and loss of sleep.

Haematosiphon inodora is a native American bug related to the bed bug, found in the Southwestern States. and Mexico. It was probably originally a parasitic messmate of birds and bats, but has how become a very important poultry pest, and in those regions due to the close association between poultry and human beings, is often a serious house pest.

TREATMENT OF BITES.

To allay the irritation caused by the bite of the bed bug, peroxide of hydrogen, or dioxygen, may be used with good results.

Tincture of iodine is also a good counter irritant.

CONTROL MEASURES.

There is practically no information on adequate methods of controlling the Triatomas.

The bed bug when badly infesting houses, may be controlled by fumigation with hydrocyanic acid gas at the rate of 10 ounces of cyanide for each 1000 cubic feet, or fumes of sulphur at the rate of five pounds per 1000 cubic feet. Such fumigation should be carried out as described on page 247.

In cases of moderate infestation it is possible at a slightly greater cost of time and personal effort, to eradicate the bugs by a liberal use of benzine or kerosene, or any of the lighter petroleum oils, introduced with small brushes or feathers, or by injecting with syringes into all crevices of beds, furniture, or walls where the insects may have concealed themselves.

Corrosive sublimate and also oil of turpentine may be used in the same way.

Careful inspection of beds and bedding, particularly mattresses, is important in any attempt to free a house of the bugs.

Travellers frequently have their luggage infested while at hotels and in trains. On arrival at home it would be well to carefully examine the clothing before putting it away.

Very frequently bed bugs are introduced into homes with laundry work which is carried to the home of the washwoman. Such wash work should be carefully inspected on receipt.

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PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY OF DISEASE, HYGIENE AND SANITATION.

Lecture 29, December 9, 1918.

A GENERAL SURVEY OF THE NEEDS OF ENTOMOLOGICAL SANITATION IN AMERICA.

W. Dwight Pierce.

Notwithstanding the great amount of publicity which has been given the Anti-fly Campaign, one will find throughout our land a rather general disregard of the danger from flies. Certain newspapers keep the subject annually before their readers, but on the whole public cooperation is slight. A few cities and communities have definitely organized mosquito control work, and the Public Health Service has done a wonderful amount of work in orgainzing such efforts. From an entomological standpoint our nation is not sanitary. The reason lies in the fact that the public does not realize that insects can and do carry disease. Science has apparently not put across the idea in such a manner that it has gripped the average person. Until we do this we cannot expect public cooperation in the attempt to put down insect spread diseases.

The problems we have to meet may be divided in several different manners. We may separate them into problems of municipalities, towns and villages, and rural communities. We may look at them from the standpoint of the farm, the home, the market, the factory, and the institution. Again they may be sorted out as problems of drainage, waste disposal, screening, animal control, etc.

Of course we have a greater diversity of entomological control problems in a municipality, but we also have more people who give attention to matters of health in a city, and who would complain against unhealthful conditions. On the other hand while the problems of the rural community and town are fewer, the insect conditions often become greatly aggravated because of total carelessness as to sanitation. This carelessness in small towns and farms is usually due either to ignorance or lack of organized effort for community betterment.

The field of the sanitary entomologist who desires to tread virgin soil is therefore to solve the ways and means of obtaining better fly and mosquito conditions in rural communities. Educational work must be carried out which will be of such nature that it will bring results. We have the theories and the scientific facts but we must give the public practical demonstrations that freedom from insect pests means reduced sickness.

Any person informed on this subject who has traveled much in rural sections of the country and seen the unobstructed entrance of

myriads of house flies to the dwellings, especially the kitchens and dining rooms and then has stepped outside and within a few feet found the open privies breeding these flies cannot help but feel a sickening sensation and a revulsion towards eating anything that the flies could have polluted. It is not at all uncommon in rural sections to see babies exposed to the unrestricted visits of flies, and their milk bottles covered with them. The writer has been informed over and over by physicians in small towns that when infantile diarrhea or any other intestinal complaint visits a town it makes the rounds of every infant in the town, unless perchance some mother is more advanced in her knowledge of such matters and keeps her baby constantly screened. When typhoid fever and dysentery visit towns with open privies and unscreened houses or hotels only the more cautious and more resistant escape. Such communities offer every conceivable opportunity for spread of the diseases by flies.

THE INSANITARY FARM.

For fifteen years the writer has traveled extensively in rural communities principally in the Southern States, where insanitary methods, if existent, aggravate disease conditions because of the more favorable climate and greater number of maladies present. We may picture therefore a few of the conditions which have been repeatedly seen in these travels, in order the better to show the problems to be met. We will not claim that these pictures represent the predominent, or the usual, or the average condition. Let it suffice that they exist sufficiently often to make them worthy of serious attention.

The farm we will describe has been seen countless times. The house has no screens on the windows, in fact often has no window panes, or may have wooden windows which are open all day. The house is one storied with an outside chimney, and an open fireplace. The chimney and fireplace offer excellent day hiding places for mosquitoes, which are abundant if there is a slough or bayou nearby. The house is built on stumps or pillars raised above the ground. The pigs and chickens, dogs and cats wander freely underneath. The house has a great open hall way through the middle, separating the bed rooms fron the dining-room. On account of the numerous flea breeding animals which pass under the house, fleas are not at all uncommon in the house. The well is usually open and built into the back portion of the porch. Mosquitoes breed in it. There is a poorly constructed, delapidated privy for the women not far from the house, but the men have none, or if they do it is not fit to enter. They usually defecate in the open, in the fields or draws, or in a woodland patch. The barn is roughly constructed. The manure is piled in great piles beside the barn, and breeds multitudes of flies. The stable floor is urine and manure soaked and affords excellent fly breeding quarters.

Naturally I have described the worst common type of farm, because on this must be built the structure for better sanitation in farm life. In many cases a large number of such places may exist on a single large

plantation, for the use of the tenants. In such cases a single man is responsible, who lives himself in a house with all modern sanitary conveniences.

The problem of the sanitarian and the sanitary entomologist is to prove to the individual farmer, and to the planter landlord the financial value of better sanitation. The planter must be shown that inasmuch as the efficiency hours of his tenants are increased in proportion will their products be increased, and in like manner his rental especially where the rental is based on certain proportions, of the crop yield. He must see that reduction of mosquitoes means reduction of malaria incidence, that reduction of flies reduces the incidence of typhoid fever, dysentery, diarrhea, and other intestinal complaints, and that as the sickness rate on the plantation is decreased the labor output is increased.

It will do us no good to theorize if we do not set down clearly the ways and means of accomplishing this greater farm output by reducing fly and mosquito breeding. In this course of lectures will be found the proofs which have been accumulated against these various insects, brief statements of how these insects live, and detailed plans of the approved methods of control.

HOW TO IMPROVE FARM SANITATION.

At this time however we may in brief state a few measures which should be taken on every farm in order to accomplish greater farm labor efficiency and improve the health of the household and of the animals.

1. The windows and doors should be screened against flies and mosquitoes. During the months that flies are not used the chimneys should have a screen over the top and the fireplace screened. If wire screening cannot be afforded, mosquito bars can be used. In the majority of cases the expenditure of the necessary amount of money to properly screen the place will be offset by a greater reduction in doctor's bills for the women and children at least.

2. Where there are many children passing in and out flies will get in. The children should be taught to use the fly swatters. No flies should ever be allowed to remain in the kitchen and dining rooms. Flies which visit food will deposit on it any disease organisms they have picked up. If the water is pure, the fly is about the only means of conveying intestinal diseases to the family.

3. Unless the babies and small children are kept indoors in screened rooms, the helpless children should have a mosquito bar over the carriage, or basket so as to protect them from flies. This is absolutely essential if there is any sickness in the neighborhood.

4. There should be installed sanitary pit or bucket privies such as are recommended by the Public Health Servide. Both men and women should be provided with such, and it should be a rule of every farm that indiscriminate defecation is absolutely forbidden. As many farms are quite large the most feasible plan would be to place at various placesabover the farm where they would be most convenient and best protected, some type of latrine, such as is used by armies, or better still a permanent privy. Because of the need for information on such matters an entire chapter is given in this volume to describing sanitary methods.

5. The well should be kept covered to prevent as far as possible mosquito breeding and contamination.

6. The foundations of the house should be boarded up to prevent the wandering of animals and to eliminate a favorite mosquito hiding place. The ground around the house should be so drained that water will not flow under the house except in case of heavy rains, and in such cases will quickly drain off from under the house.

7. All ditches, ponds and streams, and bayous on the farm should have the banks kept clear of obstructions to the free flow of the water. There should not be any tree stumps, trees, roots, weeds, or logs in the stream. The banks should not have overhanging ledges, or puddle pits. Permanent ponds and lakes might be stocked with mosquito eating fish. Places which habitually form puddles after rains should be filled or drained.

8. The barns should have hard packed dirt floors or cement floors. All manure should be removed daily from the barn. If possible the manure should be spread while fresh on fields lying out. Otherwise the manure should be piled in tight packed stacks or on platforms ofer a cement basin containing water, in order to drown the larvae migrating for pupation.

9. The garbage should be fed to pigs, preferably in sanitary feeding stalls as described by Bishopp in the lecture on the control of flies in barn yards, pig pens and chicken yards.

THE INSANITARY TOWN.

In these same travels in which so many insanitary farms were seen, the writer sojourned in or passed through many towns which might be described as follows: the streets are unpaved and are littered from one end to the other with papers, cans, the accumulation of months of manure droppings, and altogether filthy and unattractive. The removal of trash is nobody's business. The grocery stores and meat markets are unscreened and have open doors. The food is covered with flies. Farmers drive up and buy a side of salt pork or other meat, throw it into the pit of their wagons, uncovered and drive

Down the dusty road, with a swarm of flies hovering over the meat. The small lunch rooms where the visiting farmer eats his noon or evening repast are dirty and full of flies. The stores have privies in the rear which are filthy and an offense to any decent person. Flies abound. Chickens and pigs wander unrestricted through the streets and are often found feeding under the privies. The hotel is always full of flies in the dining room and kitchen, which are usually but a short distance from filthy privies, and flies are constantly passing back and forth. The bedding is often unclean and has been slept in by some one else. Bed bugs are not uncommon. The water pitchers contain mosquito wrigglers. The cisterns behind each house are unscreened and contain rain water, full of mosquitoes. The livery stable has great piles of manure in the stable yard and sometimes right out on the side walk.

Sometimes the town is a little bigger and the people have become more civilized and installed interior plumbing, which empties the sewage into a ditch which runs down to a stream from which cattle drink, or quite often this sewage empties into the gutter on the street and fills the air with filthy odors. Such is not an uncommon thing in America. Only a few years ago we could have pointed out quite a number of cities in 100,000 class with open sewage.

These small towns are often rat infested, and one can easily see the danger should an outbreak of plague which is transmitted by the rat flea, get a start in such a town, by the advent of a plague infested rat.

HOW TO IMPROVE TOWN SANITATION.

1. Organize the community for better Sanitation, and call in an expert of the Public Health Service, which is giving a great deal of attention to cooperative health work. In Russia such organizations are springing up all over the land. (Conduct a health publicity campaign

2. Conduct a Health publicity campaign.

3. Teach better sanitation in the schools and orgainze the children for clean-up work.

4. Require the screening of all stores selling food, and all hotels and restaurants dispersing food. Do not allow food to be handled in such a way that it will attract great quantities of flies.

5. Require private stables to place manure in fly tight boxes and to have same removed every 7 to 10 days.

6. Require livery stables to remove all accumulations of manure daily from the town limits.

7. Require the burning, feeding or removal of all garbage twice a week from homes and daily from hotels.

8. If garbage is hauled away and dumped the town should arrange for its daily incineration.

9. Require throughout the town limits depending upon conditions either sanitary plumbing and sewer connection, or sanitary box or pail privies. Do not allow pit privies or insanitary ones of any type. Do away as soon as possible with open sewer drainage, installing sewer pipe. Install sewage septic tanks of size adequate for the town. If there are no sewers laid it may be possible to arrange for individual installation of simple septic tanks.

10. Do not allow pigs and chickens to have access to privies.

11. Do not permit general roving of pigs, stock, chickens etc. on the town streets.

12. Keep all ditches and water ways in the town free from obstruction, and if mosquitoes are breeding, have an oiling squad.

13. Fix strict penalties against defecation on streets, alleys, and vacant lots.

14. Install a town comfort station for strangers and people from the country.

SANITARY PROBLEMS OF CITIES.

The sanitary entomological problems are multiple in large cities, and such that it would be an excellent practise to employ at least a consulting entomologist in all large cities. As a matter of fact many cities should have quite a corps of practical sanitary entomologists engaged primarily for this type of work.

City markets where meats, fish and all kinds of vegetableproduce are exposed for sale, are very attractive places for flies, and in many large cities there is gross neglect along these lines.

Sanitary inspectors need to exercise considerable vigilance in checking up obedience of ordinances relating to removal of trash, garbage, manure, excreta; insiallation of sewage or sanitary privies; proper sanitation among construction gangs; nuisances arising from stables, factories, sewage and garbage disposal plants, packing houses, stockyards, etc. Many manufacturing plants have waste products which are very attractive to insects. Insect conditions in restaurants, boarding houses and hotels should be frequently checked up.

Anti-fly and antip mosquito propaganda should be conducted annually in every city until the people are so well educated to the necessity thereof that propaganda will no longer be necessary.

The sanitary department of large cities should directly supervise mosquito suppression within its bounds.

ENTOMOLOGICAE REQUIREMENTS OF MUNICIPAL SANITATION.

The following points should be covered by ordinance in all large cities desirous of obtaining satisfactory sanitation. Not enough attention has been given by city health authorities to the insect side of their sanitary problems.

1. All food stuffs which are eaten raw, all raw meats, fish, birds, cooked foods, bread, cheese dried fruits etc. must be kept under cover of glass or screen or otherwise protected from insects, in all markets, stores, street stands, hotels, restaurants and boarding houses. Flies must not be allowed to congregate around food stalls. Cockroaches must be eliminated from all hotels, restaurants and boarding houses. Foods infested by insects should be subject to condemnation and destruction. Insect contamination of foods is dangerous.

2. Hotels, public institutions, and lodging houses shall be required to keep their premises free of bed bugs. Bed bugs carry disease.

3. All school children shall be inspected at the beginning of each new school year for head lice, and oftener if circumstances warrant. In case the children are infected they should be isolated and sent to some clinic where they can be freed of the lice. All prisoners, patients in hospitals, and applicants at municipal lodging houses should be inspected for head, body and crab lice, and if infected should be bathed and their clothing condemned or cleansed. Lice carry many diseases and every opportunity should be taken which will enable the authorities to reduce their incidence.

4. All livery stables shall be required to remove all manure to the country daily, unless specified places for dumping are set aside. All private stables should be provided with a fly proof box or a maggot-trap platform for the storage of manure and should have the manure removed at least every 10 days.

5. Garbage should be removed daily from all places where it accumulates in large quantities, and two or three times a week from private residences. All garbage awaiting removal should be kept in closed cans. Garbage must not be dumped within the city limits unless it is dumped on incinerators where fires will soon consume it. These requirements are necessary to keep down fly breeding.

6. Tin cans, bottles and receptacles which will hold water must not be allowed to accumulate in back yards, alleys or vacant lots, nor may they be dumped within the city limits or near residental sections in the suburbs, because they furnish excellent breeding for mosquitoes.

7. The city should be connected for sewers as far into the suburbs as practicable, and all suburban properties not so connected should be required to install fly proof cess pools, or septic tanks, Or to arrange by neighborhoods for independent sewage with a common septic tank; or in the absence of water and necessary plumbing to install sanitary privies, and be required to have all excreta removed once a week to an incinerator or other type of refuse disposal plant. Open vault privies should not be permitted in the city. Indiscriminate defecation on streets, alleys, vacant lots, etc. should be strictly forbidden and punishable by law.

8/ Packing houses, candy factories, syrup factories, and all other manufacturing institutions producing food products should be required to screen windows and entrances and to use fly traps in such a way as to minimize to the utmost the access of flies and other insects to the food products.

INDUSTRIAL SANITATION.

Many industries have important entomological sanitary problems in the preservation of their products from insect contamination and in the efforts to conform to sanitary regulations. There are many times when they would be able to use the services of a consulting sanitary entomologist to advantage.

The keynote of industry to day is the prevention or utilization of waste. Insect depredations on food products cause waste because the public does not want polluted food, and because sanitary inspectors are becoming more and more alive to the menace to health from insect polluted foods.

It is not generally understood that the presence of weevils and worms in cereal foods may do more than destroy the food. The evidence is growing against these insects from the sanitary standpoint. Some of these insects contain substances in their bodies which are highly toxic, as for instance Calandra granaria, the granary weevil contains the poisonous sunstance cantharidin. There are numerous instances of the sickening of animals from eating weevily grain. Still more important is the fact that where grain is accessible both to rodents and insects, certain parasitic worms pass out in the feces of the rodent in the egg stage, are eaten by the insect larvae in the grain, pass part of the cycle in the insect, and the insect is then possibly eaten by a rodent, in which the worm completes its life cycle, or sometimes in

our breakfast foods we eat these parasitized insects and become infested with the worms.

For example, the rat tapeworm, Hymenolepis diminuta Rudolphi, infests various species of rats, but sometimes is found in man. Joyeux has proven that its commonest intermediate host is the meal moth, Pyralis farinalis, which becomes infected by eating the tapeworm eggs, in its larval stage. Grassi and Rovelli found the cysticercus in the larva and adult of this moth and also in the earwig, Anisolabis annulipes and the beetles Acis spinosa and Scaurus striatus. Joueux found that the adults of the granary beetle, Tenebrio molitor easily took up the eggs.

The cysticercoid or larval stage of the rat tape worm, Hymenolepis microstoma Dujardin has been found by Grassi and Rovelli in the beetle Tenebrio molitor.

The whole problem therefore of the control of stored food products insects is of vital importance to the manufacturer of foods.

Syrup factories, sugar mills and refineries, ice cream factories, candy factories offer great attractions to flies which may alight on exposed sweets and deposit with their feet or their vomit or excreta germs of disease taken up elsewhere, perhaps days before when the fly was a larva, breeding in excrement, and these germs may find the sweets excellent culture media for extensive growth. Extraordinary means must be devised to keep flies away from such products.

Packing houses offer abundant attraction to many kinds of insects, many of which are serious disease carriers.

Railroad trains are the means of conveying from place to place disease carrying mosquitoes, flies, roaches, fleas, lice bed bugs, and mites. Fumigation of railway cars is an essential entomological control measure.

Dairies are often found to be the foci of the spread of typhoid fever, and knowing the propensity of the house fly we can see how readily it can carry the organism from the stools of a sick person to the milk pails in the dairy. There needs to be rigid control of flies in all dairies.

These are but examples of many industries which have problems in sanitary entomology.

PROCEEDINGS OF THE CLASS FORMED TO STUDY THE ENTOMOLOGY

OF DISEASE, HYGIENE AND SANITATION.

Lecture 30, RELATION OF INSECTS TO THE PARASITIC WORMS OF

December 16, 1918. VERTEBRATES.

By B. H. Ransom.

The only important part insects are known to play in the propagation of parasitic worms that affect human beings and other vertebrates is that of true intermediate hosts necessary to the existence of the parasites in some of their stages of development. Observations have been recorded in the literature showing that flies and other insects may swallow the eggs of various parasites of man such as hookworms, whipworms, and other nematodes in whose life history no intermediate hosts are required, also the eggs of tapeworms in whose normal life history it is known that insects are not concerned, for example, Taenia saginata whose intermediate host is the ox. It has been supposed that insects may thus act as mechanical carriers for such parasites, but as a matter of fact definite evidence of the importance of insects as mechanical carriers of the eggs or larvae of parasitic worms has not yet been brought forth. On the contrary there are reasons to suppose that in some cases at least the swallowing of the eggs or larvae of parasites by insects that can act only as mechanical carriers and not as intermediate hosts reduces rather than increases the chances of the young parasites continuing their development and reaching a host in which they can become mature. Among the parasitic worms affecting man and other vertebrates it is those forms requiring intermediate hosts, so called heteroxenous parasites, that are of special interest so far as insect transmission is concerned. The monoxenous parasites, or those requiring no intermediate host may practically be left out of consideration, with the admission that the mechanical carriage of monoxenous parasitic worms by insects may in the future be proved to have an importance not yet demonstrated.

A complete demonstration of the part played by an insect in the life history of a given species of parasite is often a difficult matter. The animal which serves as the final host may be subject to infestation not only with the species of parasite under investigation but also with other species liable to be confused with it in some of its stages. The insect may likewise harbor parasites other than the one that is being studied. The possibilities of confusion and of the entrance of extraneous factors into the problem are so many and so varied, that in most cases it is only after the most rigorously controlled experiments combined with careful comparative studies of the successive stages of the parasite that conclusions may safely be drawn. Furthermore working out the life history of a parasitic worm it is not sufficient to prove that

insects of a certain species can act as intermediate hosts under experimental conditions. Some species of parasitic worms are able to develop in more than one species of insect, and the fact that a certain parasite can develop in a certain insect does not necessarily mean that under natural conditions the species of insect in question serves as the intermediate host of the parasite. For example, one of the common parasites of sheep and cattle is able to pass through its larval stages in cockroaches. These insects become readily infected if the eggs of the parasite which occur in the feces of the final host animals are fed to them. Under natural conditions however cockroaches do not ingest the feces of sheep and cattle nor are they found in places where they are likely to be picked up by sheep and cattle. Besides cockroaches various species of dung beetles have been shown to be capable of acting as intermediate hosts of the parasite in question, and it is evident that these insects are the natural intermediate hosts. Unlike cockroaches they have plenty of opportunity both of becoming infected and of passing on their infection to the final hosts.

A more or less intimate environmental relationship between the insect host and the final host generally exists in the case of parasites transmitted by insects. In a number of cases the insects are coprophagous and also likely to be ingested by the final hosts as in the instance just cited. Another highly interesting group of cases is that in which the insects are ectoparasites on the final hosts, or bloodsuckers that periodically visit them, and thus have particularly favorable opportunities for becoming infected with parasitic worms harbored by the animals they attack and in turn reinfecting the latter.

Mode of infection of insect hosts.

As already stated the part which insects may take in the propagation of parasitic worms of higher animals is that of intermediate hosts, in which certain larval stages of the parasites are passed before they develop to maturity. The way in which the insects become infected varies with different species of parasites. In the case of some species which live in the alimentary tract of the final host the eggs or larvae are discharged from the body of the host in the feces. Coprophagous insects swallow the eggs and if they are suitable intermediate hosts for the parasites the young worms go through several developmental stages and finally within the bodies of the insects reach a stage in which they are ready to be introduced into the bodyof the final host. Certain parasites whose adult stages live in relation with the blood vessels of the final host discharge their young into the blood stream whence they may be ingested by blood sucking insects in whose bodies they undergo development to a stage infective for the final host. Aquatic insects may swallow free living larval stages of parasites, or may be actively attacked by larval parasites which gain entrance to their bodies by penetrating the cuticle. These insects may in turn be eaten by other insects and the infection thus passed on to them.

In some cases the parasites may be taken up by insects or enter their bodies during an early stage of development of the insects and persist in later stages. Infection may thus occur during one stage of the insect but the development of the parasite to a stage infective for the final host may not be completed until after the insect has reached a later stage. Thus flies become infected with a certain parasite of the horse during the maggot stage, but the young parasites do not become sufficiently developed to be returned to the final host until the flies have reached the pupal or adult stage.

Mode of infection of vertebrate hosts.

Parasitic worms that have insects for intermediate hosts reach their final hosts in various ways. In the case of some species the insect hosts are swallowed either as the habitual food of the final hosts, or incidentally with food or drink. In other instances the young worm may have already escaped from its insect host before it is taken in with food or drink by its final host. The cases of accidental infection with horse-hair worms not normally parasites of human beings are likely to have happened in this way. The parasites of which blood sucking insects are intermediate hosts may be introduced into their final hosts as a result of the escape of the larval parasites from the insects at a time when the insects are drawing blood. Commonly the larvae burst through a weak spot in the cuticle of the insect and then burrow into the skin of the final host.

The parasitic worms of the higher animals in whose life history insects and insect-like organisms play a part belong to two large zoological groups, Plathelminthes and Nemathelminthes. The former may be subdivided so far as concerns parasitic forms into Cestoda, or tapeworms, and Trematoda or flukes; the latter into Nematodes, or roundworms in the restricted sense, Gordiacea or horse-hair worms, and Acanthocephala, or thorn-headed worms.

CESTODA OR TAPEWORMS.

All tapeworms whose life history has been well established require intermediate hosts, and are thus heteroxenous parasites. A typical life history of a tapeworm is as follows: The adult lives in the intestine of the final host. The eggs pass out of the body of the infested animal in the feces . The feces or food or drink contaminated by them are swallowed by an animal that can act as an intermediate host. The eggs thus reaching the intermediate host hatch in the alimentary tract and the embryos set free, migrate into near by or remote tissues of the body, developing finally into an intermediate stage commonly of the type known as a cysticercoid in the case of those tapeworms whose intermediate stages occur in insects. Having reached this stage further development awaits the time when the intermediate host or infested portions of its body are swallowed by an animal that can act as the final host,

whereupon it resumes its development and becoming mature completes the life cycle. About 100 species of tapeworms are known whose adult stages occur in man or domestic animals. Four of these, Dipylidium caninum (the double-pored tapeworm of the dog, cat, and man), Hymenolepis diminuta (the yellow-spotted tapeworm of rats, mice, and man), Hymenolepis nana (the dwarf tapeworm of rats, mice, and man), and Choanotaenia infundibulum (one of the tapeworms of the domestic fowl), have insects as intermediate hosts, with the possible exception of the dwarf tapeworm in whose life history the part played by insects has not been definitely determined.

Dipylidium caninum (Linnaeus, 1758) Railliet, 1892.

This tapeworm, sometimes called the double-pored dog tapeworm is of very common occurrence in the small intestine of dogs and cats, and of occasional occurrence in human beings. Its larval stage (cysticercoid) occurs in the biting dog louse (Trichodectes canis) as determined experimentally by Melnikov (1869) and in fleas (Ctenocephalus canis, C. felis, and Pulex irritans). Fleas apparently are the usual intermediate hosts. Grassi and Rovelli (1888,1889) followed the various stages of larval development in adult fleas, from the hexacanth embryo to the fully developed cysticercoid, and as they failed to find the parasite in larval fleas concluded that only adult fleas can act as hosts. Recently, however, Joyeux (1916) has reached the conclusion that adult fleas are unable to swallow the eggs of the tapeworm. He finds that larval fleas readily swallow the eggs; these hatch in the intestine of the insect, and the embryos thus released penetrate into the body cavity. They persist in the hexacanth stage until the transformation of the flea into the adult, after which they proceed with their development and in a short time reach the cysticercoid stage. Infection of the dog, cat, or human being occurs naturally as a result of swallowing infested fleas. Fleas are exposed to infection owing to the fact that their larvae live in an enviornment likely to be contaminated by the feces of infected dogs or cats. The eggs of the tapeworm as passed in the feces are grouped in capsules containing about a dozen eggs so that infection of the insect host is likely to be multiple. The double-pored tapeworm is relatively uncommon in man and most of the cases recorded, of which there have been less than 100 all told, three in the United States, are among children. Children are more likely than adult human beings to swallow fleas which would explain the greater frequency of infestation among children. Another possible explanation of the more common occurrence of this parasite among children than among adults in that older persons may possess a greater immunity to infection. Prophylaxis against the double-pored tapeworm consists chiefly in keeping dogs and cats free from lice and fleas, and so far as human beings are concerned excluding dogs and cats, especially if they are lousy or infested with fleas, from human habitations.

Hymenolepis diminuta (Rudolphi 1819) Blanchard, 1891.

Hymenolepis diminuta (the yellow spotted tapeworm) is of frequent occurrence in the small intestine of rats and mice, particularly

the former, and of occasional occurrence in the intestine of man. The adaptability of the adult tapeworm to hosts so widely different as rodents and human beings is paralleled by the adaptability of the larval stage to various intermediate hosts. Cysticercoids belonging to this species have been recorded in various insects, a Lepidopteron, Asopia farinalis, in both larva and imago, an Orthopteron, Anisolabis annulipes, Coleoptera, Alphitobius diaperinus, Tribolium confusum, and Tenebrio molitor, and fleas, Ceratophyllus fasciatus, Xenopsylla cheopis, Pulex irritans, and Ctenocephalus canis, also in myriapods, Fontaria virginiana and Julus sp. Nicoll and Minchin (1911) found the cysticercoids in about 4 per cent of the rat fleas (8 out of 207) they examined during a period of thirteen months, and they succeeded in infecting rats with the tapeworm by feeding them fleas, as Grassi and Rovelli (1892) had previously done by feeding other insects. Joueux (1916) infected the larvae of Asopia farinalis by feeding the eggs of H. diminuta and believes the cysticercoids recorded in the adult moth by Grassi and Rovelli were carried over from the larval stage of the insect. He failed in his attempts to infect Forficula auricularia, Periplaneta orientalis, and Blatella germanica. He also failed to infect beetles belonging to the species Blaps mortisaga, but succeeded easily in infecting the adults of Tenebrio molitor. The larvae of this latter beetle according to Joyeux are incapable of acting as intermediate hosts of H. diminuta. He was able to infect the larvae of rat fleas and of Pulex irritans and Ctenocephalus canis. In these insects the embryos of H. diminuta begin immediately to develop into cysticercoids and do not wait for the transformation of the larval fleas into adults, as Joyeux found in the case of Dipylidium caninum, the embryos of which apparently lie dormant in the insect until after it transforms into the adult stage. In this country Nickerson (1911) has reared the cysticercoid in myriapods, Fontaria virginiana and Julus sp. fed on the eggs of the tapeworm. He failed in his attempts to infect meal worms.

It is evident that infection of the difinitive host with H. diminuta results from swallowing infested insects, the latter having become infested as a result of swallowing the eggs contained in the feces of animals harboring the tapeworms. As a parasite of man in the United States so far as available statistics show H. diminuta ranks about third in frequency among the tapeworms, the beef tapeworm (Taenia saginata) being the most common, and the dwarf tapeworm (H. nana) being next. Evident prophylactic measures are those directed toward the destruction of rats and mice and the avoidance of the ingestion by human beings of the various insects that may serve as intermediate hosts, especially the protection of farinaceous foods from insect infestation.

Hymenolepis nana (Siebold, 1852) Blanchard, 1891.

Hymenolepis nana (the dwarf tapeworm) is a very common intestinal parasite of rats and mice and is of rather frequent occurrence in man, especially in children. In the United States it ranks second to the beef tapeworm in the order of frequency among the tapeworms of man. Its life history has not been fully worked out. Grassi (1887), however has found

that cysticercoids develop in the intestinal villi of rats that have been fed the eggs of the dwarf tapeworm. According to his view the cysticercoids later break out of the villi into the lumen of the intestine and grow into mature tapeworms. The rat thus acts both as intermediate and definitive host of the dwarf tapeworm, the parasite being spread from one rat to another through the medium of the eggs passed in the feces. The dwarf tapeworm according to Grassi's version of the life cycle is an exception to the rule among tapeworms that the adult stage occurs in one species of animal and the larval stage in another species likely to be eaten by animals of the species that harbors the adult tapeworm.

Inasmuch as Nicoll and Minchin (1911) have found cysticercoids in a rat flea (Ceratophyllus fasciatus) that in details of head structure are apparently exactly similar to and specifically identical with the dwarf tapeworm, the question arises whether such insects may not act as intermediate hosts, and whether in addition to the life cycle of an exceptional type described by Grassi, the dwarf tapeworm also has a life cycle of the ordinary type. T.H. Johnston has found cysticercoids similar to those recorded by Nicoll and Minchin in another species of rat flea (Xenopsylla cheopis) as well as in Ceratophyllus fasciatus.

Joyeux (1916) has failed in experiments with fleas belonging to the species named and to related species, to infect them with H. nana. He states he used both larval and adult fleas. On the other hand he was able to confirm Grassi's results and succeeded in infecting a large number of rats and mice by feeding them the eggs of the tapeworm. The experimental evidence thus far available accordingly favors the view that insects do not play a necessary part in the life history of the dwarf tapeworm. Furthermore considering the frequency of occurrence of H. nana as a parasite of man, and the enormous numbers of the parasites sometimes present, it would seem that infection is more likely to occur in the manner described by Grassi than as a result of swallowing rat fleas, there being of course a greater likelihood of human beings swallowing rat feces or fecal matter from other human beings containing large numbers of eggs of the tapeworm than of swallowing rat fleas containing a sufficient number of cysticercoids to develop into the large number of tapeworms that have been found in some cases.

Choanotaenia infundibulum (Bloch, 1779) Cohn, 1899.

Choanotaenia infundibulum is a common tapeworm of chickens in various parts of the world. Grassi and Rovelli (1882) in Italy found cysticercoids in the common house fly (Musca domestica) which on account of their morphological similarity to Choanotaenia infundibulum they inferred belonged to this species. From the results of experiments conducted in this country by Gutherlet (1916) it appears safe to conclude that the common house fly acts as the intermediate host of the tapeworm, Choanotaenia infundibulum, infection of the fly apparently occurring as a result of swallowing eggs of the tapeworm, and the chicken in turn acquiring the parasite as a result of swallowing flies infested with the cysticercoid stage. Whether infection of the fly regularly occurs during the larval or during the adult stage, or during both stages, has not been definitely settled.

Prophylaxis in the case of this tapeworm is obviously largely dependent upon fly control measures.

Other tapeworms.

According to Villot (1883) the larval tapeworm observed by Stein (1852) in the larva of Tenebrio molitor belongs to the tapeworm of the mouse known as Hymenolepis microstoma. The same writer (1878,1883) also associates with certain tapeworms of shrews two species of larval tapeworms which be found in myriapods, Glomeris limbata. Further investigation of these parasites appear necessary to substantiate the views held by Villot as to their specific identity.

TREMATODA OF FLUKES.

All species of flukes whose life history is known depend upon molluscs as hosts for certain larval stages and they may or may not require one or more additional intermediate hosts before they reach the definitive host. It is as intermediate hosts following the first intermediate host, a mollusc, that insects can play a part in the propagation of flukes. As yet it has not been shown that insects are concerned in the life history of any of the flukes (about 100 known species) that affect human beings or domestic animals, but as the life history of all of these parasites has not been determined it is quite likely that in the case of some species insects will be found to act as intermediate hosts. Different species and groups of species show various types of life history with reference to the number of larval stages through which the parasite passes and the number of intermediate hosts required. A comparatively simple life cycle is as follows: The mature fluke in the definitive host produces eggs which pass to the exterior in the feces. Under suitable conditions of moisture and temperature the egg hatches and a ciliated larva, the miracidium, issues. If this miracidium finds a suitable mollusc (different species of molluscs attract different species of miracidia) it burrows into the soft tissues of the mollusc and reaching the respiratory chamber proceeds to develop into the next stage, the sporocyst. Within the sporocyst by a process of internal budding more or less numerous so-called rediae develop. The rediae finally leave the sporocyst and migrate into the liver of the mollusc. In the redia several generations of daughter rediae may develop by budding. The next stage developed also by internal budding from the redia is the cercaria. The cercaria of some species is provided with a tail by means of which it swims about in the water when it finally escapes from the mollusc. The cercaria may be swallowed by or actively penetrate into some animal and become encysted in this animal. Finally when the animal harboring encysted immature flukes is swallowed by an animal which can serve as a host of the adult fluke the young flukes thus reaching their definitive host develop to maturity and the life cycle is complete.

Following is given a partial list of the insects in which young flukes have been recorded. The species to which the young flukes in ques-

tion have been assigned and the final host animals are also indicated. Further investigations are likely to show that some of the flukes from insects have been misidentified and do not belong to the species to which they have been supposed to belong, and the data given in the list should be accepted as fully proved in any case, though there can be no doubt in some of the cases cited. No distinction has been made between certain and doubtful cases, except that a few that are doubtful are indicated by question marks. The determination of species of young flukes found in insects has generally been made solely upon their morphological similarity to adults occurring in vertebrate hosts and it is quite likely that mistakes have been made by investigators of these parasites just as mistakes have frequently been made in the association of immature and adult parasites belonging to other groups of worms.

Insect host.	Adult fluke	Final host.
Coleoptera:		
Ilybius fuliginosus (adult)	Haplometra cylindracea	Frogs
Water beetle (larva)	Prosotocus confusus	"
" " "	Pleurogenes medians	"
" " "	Pleurogenes claviger	"
Lepidoptera:		
Hydrocampa nymphaeata (larva)	Unknown	Unknown
Diptera:		
Anopheles claviger (adult)	Unknown	"
" maculipennis (adult)	"	"
" ROSSI (adult)	"	"
Chironomus plumosus (Larva)	Lecithodendrium ascidia	Bats
Culex fatigans (adult)	Unknown	Unknown
Neuroptera:		
Anabolia nervosa	Allocreadium isoporum	Cyprinoid fishes
Anabolia nervosa (larva)	Opisthioglyphe rastellus	Frogs
Chaetopteryx villosa (larva)	Allocreadium isoporum	Cyprinoid "
Cloeon dipterus (larva)	?Opisthioglyphe rastellus	Frogs.
Drusus trifidus (larva)	Unknown	Unknown
Epithoca (larva)	Gorgodera cygnoides	Frogs
" "	" pagenstecheri	"
" "	" varsoviensis	"
Limnophilus rhombicus (larva)	Opisthioglyphe rastellus	"
" griseus (larva)	" "	"
" lunatus (larva)	" "	"
" flavicornis (L)	" "	"
Mystacides nigra (larva)	Unknown	Unknown
Notidobia ciliaris (larva)	"	"
Phryganea sp.	Lecithodendrium chilostomum	Bats
" grandis (larva)	Unknown	Unknown.
Rhyacophila nubila (larva)	"	"
Sialis lutaria (larva)	"	"

Orthoptera:		
Aeschna (larva & adult)	Prosotocus confusus	Frogs.
Agrion (larva)	Gorgodera pagenstecheri	"
" "	" varsoviensis	"
" "	Pleurogenes medians	"
Calopteryx virgo	Halipegus ovocaudatus	"
" " (larva & adult)	Pneumonoeces similis	"
Cordulia (larva)	Prosotocus confusus	"
Ephemera vulgata (larva)	Allocreadium isoporum	Cyprinoid fishes
" " "	?Opisthioglyphe rastellus	Frogs
Ephemeridae (larvae)	Lecithodendrium ascidia	Bats
Perlidae (larvae)	" "	"
" "	Unknown	Unknown

NEMATODA OR ROUNDWORMS.

Among parasitic worms the species of nematodes are more numerous than either the species of tapeworms or flukes. Nematodes as a group are not exclusively parasitic and thousands of free living species are known to exist although comparatively few have been described. Many species of nematodes are parasites of insects only and do not occur in other animals. Insects therefore harbor parasitic nematodes which belong to them exclusively as well as the larval stages of nematodes that occur in higher animals in their adult stage. The ubiquity of free-living nematodes introduces a frequently troublesome complication into the study of the life-histories of monoxehous parasitic nematodes of which there are many species, and the common occurrence of parasitic nematodes among insects introduces an equally troublesome complication into the study of the life-histories of the heteroxenous nematodes parasitic in higher animasl for which insects may serve as intermediate hosts. About 250 species of nematodes have been recorded as parasites of man and domestic animals. Many of these require no intermediate hosts, but some are heteroxenous parasites, and a number of these are known to have intermediate stages in insects and closely related arthropods. In the following discussion, in addition to the nematodes parasitic in man and domestic animals, certain species parasitic in other animals are also considered because of the part played by insects in their life-history. For convenience they may be placed in two groups, (1) those in which the eggs or first-stage larvae leave the body of the final host in the feces, and (2) those in which the first-stage larvae occur in the blood or lymph of the final host and leave the body through ingestion by blood-sucking insects.

(1) Parasitic nematodes whose eggs or larvae leave the body of the final host in the feces.

Protospirura muris (Gmelin, 1790) Seurat, 1915.

This nematode parasitic in its adult stage in the stomach of various species of rats and mice is of special interest historically as being the

first parasite in whose transmission to its final host an insect was found to be concerned. Stein in 1852 recorded the presence of encysted nematodes in the larvae of meal beetles (Tenebrio molitor). Leuckart (1867) and Marchi (1867) fed eggs of Protospirura muris (Spiroptera obtusa) to meal beetle larvae and followed the development of the young nematodes up to the encysted stage found by Stein. This development is completed in about six weeks after ingestion of the eggs. The development to the adult stage was also followed in mice fed with the encysted nematodes from meal worms. Johnston (1913) has recorded encysted nematode larvae which appeared to him identical with those of P. muris in the body cavity of a rat flea (Xenopsylla cheopis).

Spirocerca sanguinolenta (Rudolphi 1819) Railliet & Henry, 1911.

The adults of this nematode live in tumors of the stomach and esophagus of the dog and the wolf. The eggs unhatched pass out of the body of the dog in the feces. Grassi (1888) found encysted larval nematodes in cockroaches (Periplaneta orientalis) which he suspected were the larvae of S. sanguinolenta. Dogs fed with these encysted nematodes after five days showed the larvae free in the stomach; after ten days the young worms were further developed and were firmly attached to the mucosa of the esophagus; and after fifteen days they had sunk themselves into the wall of the esophagus and had developed still further. Grassi concluded that cockroaches act as intermediate hosts, swallowing the eggs in the feces of infested dogs, and in turn being swallowed by dogs. Seurat (1913), however believes that Grassi was mistaken as to the identity of the encysted nematodes found in the cockroaches, and that they were really the larvae of Spirura gastrophila, the adult of which occurs in the stomach of the cat, hedgehog (Erinaceus algirus), and fox (Vulpes vulpes atlantica). Seurat (1912, 1916) finds what he considers to be the larvae of S. sanguinolenta encysted in a great variety of animals including beetles, reptiles, birds, and mammals. The presence of the encapsulated larvae in various vertebrates he explains as the result of the ingestion of insects infested with the larvae. If the vertebrate is not a host in which the parasites can continue their development as they would in their normal host the dog, they migrate into the wall of the alimentary tract or mesentery and become reencysted without further development. If, however, the infested insect is swallowed by a dog the larvae after they have been freed by digestion of the cysts surrounding them continue their development and finally reach maturity. Seurat in fact found that encysted larvae in insects identified as those of S. sanguinolenta when fed to mice became reencysted in the manner described. Seurat (1916) records the following insects as hosts of the larvae of S. sanguinolenta, all of them beetles: Scarabaeus (Ateuchus) sacer, Scarabaeus variolosus, Acis goryi, Geotrypes douei, Copris hispana, and Gymnopleurus sturmi. According to Seurat the life cycle of S. sanguinolenta would be as follows: The eggs pass out of infested dogs in the feces, are ingested by beetles, hatch, and the larvae after a period of growth and development become encysted. If infested insects are swallowed by dogs the larval worms are released from their capsules and develop to maturity. If the insects are swallowed by animals, other than dogs, the larvae may become freed from their cysts as

in the alimentary tract of the dog, but they are unable to develop further and leave the lumen of the alimentary tract and become reencysted in the tissues through which they migrate. In such a case, of course, there is a possibility of their resuming their development if the infested animal should afterwards be devoured by a dog, but this possibility apparently has not yet been substantiated.

Spirura gastrophila (Mueller, 1894) Marotel, 1912.

This nematode occurs in the stomach and the lower end of the esophagus of the cat. It has also been recorded by Seurat (1913) from the stomach of a hedgehog (Erinaceus algirus) and the stomach and esophagus of a fox (Vulpes vulpes atlantica). This author identifies certain encysted larval nematodes found in species of Onthophagus, in Periplaneta orientalis, in Blaps strauchi, and in Blaps sp. (near appendiculata) as belonging to S. gastrophila. He thinks the parasites found in the cockroach and called Filaria stipleuritas by Deslongchamps (1824) and those identified as such by Galeb (1878) who associated them with an insufficiently described adult nematode of the rat, are probably the same as those he identifies as the larvae of S. gastrophila. He also dismisses Grassi's experiments as insufficient to show that the nematodes encysted in cockroaches are the larvae of Spirocerca sanguinolenta as Grassi believed, and concludes that Grassi was mistaken and was really dealing with the larvae of Spirura gastrophila.

Gongylonema scutatum (Maeller, 1869)Railliet, 1892.

This nematode in the adult stage is a common parasite in the mucous membrane of the esophagus of cattle, sheep, and other ruminants, and has also been recorded from the horse. Ransom and Hall (1915,1916,1917) have shown that various species of dung beetles (Aphodius femoralis, A. granarius, A. fimentarius, A. colorandensis, A. vittatus, Onthophagus hecate, and O. pennsylvanicus) act as intermediate hosts. Experimentally cockroaches(Blatella germanica) can also be made to serve as intermediate hosts, a part of course which they do not play under natural conditions. The eggs of the parasite pass out of the body of the difinitive host in the feces and are swallowed by dung beetles. They hatch in these insects, and the larvae entering the body cavity undergo a certain growth and development, reaching their infective stage in about a month, meanwhile becoming enveloped in capsules in which they lie in a coiled up condition. Further development waits upon the swallowing of the infested insect by a cow, sheep, or other suitable host as may readily occur while the animal is grazing, the insect being ingested with the herbage upon which it happens to be. Following their ingestion by the definitive host, the larvae are released from their capsules and develop to maturity.

Gongylonema mucronatum Seurat, 1916.

This nematode occurs in the adult stage in the mucosa of the esophagus of the Algerian hedgehog (Erinaceus algiris). According to Seurat

(1916) its larval stage is found encapsuled in the body cavity of various species of coprophagous beetles, Ateuchus sacer, Onitis irroratus, Onthophagus bedeli, Gymnopleurus nopsus, Gymnopleurus sturmi, and Geotrypes douei but there appears to have been some confusion as to the identity of the larvae in question, and further investigation of the life history of this species is necessary (Ransom & Hall, 1917).

Gongylonema neoplasticum (Fibiger & Ditlevsen, 1914) Ransom & Hall, 1916.

This nematode occurs in the adult stage in the mucosa of the stomach, esophagus and mouth of the rat. It has been reared experimentally in the rabbit and guinea pig as well as in the rat and mouse. It is of special interest from the medical standpoint because it is commonly associated with and perhaps stands in etiological relationship to gastric carcinoma of rats. Fibiger and Ditlevsen (1914) have proved that cockroaches (Periplaneta americana, P. orientalis, and Blatella germanica) and a grain beetle (Tenebrio molitor) can act as intermediate hosts. The eggs are passed in the feces of infested rats and if ingested by one of the insects named will hatch, the larvae within twenty days after ingestion of the eggs developing to the infective stage. In this stage the larvae are coiled up in cysts in the muscles of the prothorax and legs, differing in location from the larvae of G. scutatum which in artificially infected cockroaches as in their normal hosts, dung beetles, are found encysted in the body cavity.

Arduenna strongylina (Rudolphi, 1819)Railliet & Henry, 1911)

This nematode in its adult stage occurs in the stomach of the pig. Seurat (1916) has recorded the presence of larval nematodes in the stomach of a pig associated with adults of A. strongylina which he considers belong to this species. He has found morphologically similar larval nematodes encapsuled in the body cavity of Aphodius castaneus and states that they also occur in beetles of the genus Onthophagus. Apparently no feeding experiments have been carried out. Presumably the life history would be similar to that of Gongylonema scutatum, Protospirura muris etc., that is, the eggs of the parasite passed in the feces are swallowed by beetles, the larvae develop in these insects to the infective stage, and are transferred to the definitive host when the beetles are swallowed by a pig, after which the young worms complete their development to maturity.

Physocephalus sexalatus (Molin, 1860)Diesing, 1861.

The adults of this nematode live in the stomach of the pig, dromedary, and donkey. Seurat (1913) has found two successige larval stages preceding the adult in the stomach of the definitive host (donkey) and has also (1916) established the common occurrence of the earlier of these two stages in various dung beetles (Scarabaeus (Ateuchus) sacer, S. (A) variolosus, Geotrypes douei, Onthophagus nebulosus and O bedeli). Pigs

of course are commonly known to be coprophagus in their habits and Seurat states that the donkeys of Algeria where his investigations were made commonly devour fecal matter swarming with dung beetles. The way in which the larvae of P. sexalatus reach their final host is therefore evidently through the ingestion of infested beetles by pigs, donkeys, or dromedaries. Presumably of course the beetles become infested by eating the eggs of the parasite which are passed in the feces of infested pigs, donkeys and dromedaries. As in the case of Spirocerca sanguinolenta Seurat finds encysted larvae of P. sexalatus in various vertebrates in Algeria particularly reptiles and insectivores. Their presence in these animals he would explain in the same way as he explains the presence of the encysted larvae of S. sanguinolenta in such animals, that is, the larvae present in insects devoured by the animals in question are unable to continue their development as they would in pigs and other suitable hosts. On the other hand they do not succumb in their strange environment nor do they pass through the alimentary tract with the feces but penetrate into the walls of the stomach and into other tissues and become reencysted, surviving in this condition more or less indefinitely. They may thus be considered parasites that have gone astray but still capable of existence in their abnormal environment. The possibility of their developing to maturity after reencystment in a strange host if this animal should be eaten by a pig has not been substantiated experimentally.

Seurat (1916) has counted 4,880 larvae identified as P. sexalatus in a single beetle (Scarabaeus (Ateuchus) sacer). In addition there were 68 larvae of Spirocerca sanguinolenta in the same beetle making a total of 4,948 larvae in the one insect.

Habronema muscae (Carter, 1861) Diesing, 1861.

This nematode in the adult stage occurs in the stomach of horses and other equines, commonly in association with another closely related species, H. microstoma. The life history of H. muscae has been shown to be as follows (Ransom, 1911, 1913): The eggs or the larvae pass out of the body of the host in the feces. They enter the bodies of the larvae of the common house fly probably being swallowed though the mode of entrance has not been determined by direct observation. The worm larvae grow and develop in the developing flies and at about the time the adult insects emerge from the pupal stage the larvae reach the infective stage. In this stage they are most commonly found in the proboscis. The ingestion of flies harboring the larvae by horses brings the young parasites into the location where the adult occurs, and presumably this is the common method by which the larvae reach their final host. The frequent swallowing of flies by horses is an undoubted fact. The mouths of horses are very attractive to house flies especially while the horses are eating as any one can determine by a few minutes' observation of the animals during the fly season. There is also another possible and very probable way in which the larvae are transferred to horses, suggested of course by the habit of the larvae of congregating in the proboscis of the fly. We may expect that it will be demonstrated in analogy with what has

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been shown to occur in Filaria transmission by mosquitoes that the larvae of H. muscae can actively leave the proboscis of the fly while the insect is sucking moisture from the mouth of lips of the horse. There is already indirect evidence that this does occur. The researches of Descazeaux (1915) and Bull. (1916) have shown that the nematodes which occur in cutaneous granulomata and so-called summer sores of horses are morphologically similar to the larvae of Habronema muscae and in all probability belong to this or a closely related species. The presence of Habronema larvae in these sores is strongly suggestive of their introduction by flies. Whether they are able to migrate to the stomach and complete their development to maturity remains to be determined.

It is of interest to note that Habronema muscae was known as a parasite of the fly long before its relation to the horse was demonstrated. Carter in 1861, was the first to record the presence of the nematodes in flies, following which they were frequently observed by entomologists and others who had occasion to examine the proboscis of the fly under the microscope.

Larval nematodes very similar to H. muscae have been seen in the proboscis of Stomoxys calcitrans by Johnston and others. A careful comparison of these larvae with those of H. muscae appears not to have been made. If they are not identical there is a possibility of their belonging to the other species of Habronema mentioned, namely H. microstoma.

The fact that these more or less injurious parasites of the horse depend upon flies for their existence is a point which may be added to those commonly used in arguments for the necessity of fly eradication. The possibility is also not excluded that flies may introduce Habronema larvae into human beings, in whose tissues they may perhaps be able to live for a time and do considerable damage. Though there is no evidence that this ever occurs, the possibility is one that deserves consideration from those who have opportunity to investigate the relation of flies to wounds and other lesions of the skin and mucous membranes.

Acuaria nasuta (Rudolphi, 1819) Railliet, Henry & Sisoff, 1912.

The adults of this nematode have been recorded as parasitic in the stomach of the domestic fowl and the sparrow. Insects have not been shown to act as intermediate hosts, but insect-like animals commonly known as sow-bugs have been suspected, Piana (1897) having found larval nematodes in an isopod (Porcellio laevis) that he considered probable intermediate stages of A. nasuta.

Ascaris lumbricoides Linnaeus, 1758.

This common parasite of man has been definitely shown to have a direct life history without intermediate host. The opinion of Linstow (1886) that a species of Julus (guttulatus) acts as the intermediate host is without foundation. The common house-fly may swallow eggs of this

parasite as well as those of various other parasites which occur in the feces of infested human beings. The eggs pass through the intestine of the fly unhatched. Flies may thus scatter the eggs of Ascaris but there is no evidence that mechanical carriage of the eggs in this way assists materially in the spread of the parasite. There are various other natural agencies more effective than insects in spreading infection with parasites such as Ascaris.

(2) Parasitic nematodes whose first-stage larvae occur in the blood or lymph of the final host and leave the body through ingestion by blood-sucking insects.

Filaria bancrofti, Cobbold, 1877.

This important parasite of man is widely distributed throughout the world in tropical and subtropical countries. It occurs in the United States though apparently by no means common. Historically it is of special interest because of the fact that it is the species which Manson (1878) showed passed through certain metamorphoses in the bodies of mosquitoes after the larvae had been sucked up by these insects in the blood of human beings affected with filariasis. Manson's researches coupled with confirmatory work by other investigators established the novel fact of the transmission of an animal parasite by a blood-sucking insect, and may be taken as the starting point in the development of our knowledge concerning the part played by such insects in the spread of disease-causing organisms. Lewis had also observed the passage of the larvae from the human host into mosquitoes. The first observation of these larvae in man was recorded by Demarquay in 1864 in Paris, the adult female was discovered by Bancroft in 1876 in Queensland, and the adult male by Bourne in 1888.

The adults of this species live in the lymphatic system, both vessels and glands. The first stage larvae which are provided with a thin cuticular sheath, apparently the transformed egg shell, are found in the blood stream, usually periodically as first shown by Manson, that is, in considerable numbers only at night or rather during the hours of sleep, as the periodicity may be reversed by making the patient sleep during the day time. One of the names of the parasite, Filaria nocturna, is based upon the periodicity of the appearance of the larvae in the blood. Various pathological conditions have been attributed to Filaria bancrofti such as adenitis, lymphangitis, abscesses, lymph-scrotum, chyluria, and other disturbances of the lymphatic system. The connection between filariasis and elephantiasis is still a matter of argument among pathologists.

When taken into the stomach of a mosquito the larvae lose their cuticular sheaths. Within 24 hours they leave the alimentary tract, pass into the body cavity, then into the muscles of the thorax. In the muscles they become shortened to about half their original length and fern-

while increase to twice or more than twice their original thickness, developing into what is known as the sausage stage of general occurrence in the development of Filaria larvae. Developing beyond this stage they increase rapidly in length, cast their skin at least once, and in one to two weeks after infection of the mosquito, or longer, according to temperature and the species of mosquito infested, they complete their larval development so far as the intermediate host is concerned, reaching a length finally about three to five times the length of the first-stage larvae

and a thickness about three or four times the original thickness. They leave the muscles, enter the body cavity, and migrate into various locations, posterior portions of body, legs, palpi, but in greatest numbers into the labium. From the evidence afforded by the experiments of Noé (1900) with Dirofilaria immitis and additional experiments by Bancroft (1901), Lebredo (1904,1905) Fülleborn (1908) and others, it has been concluded by analogy in the case of Filaria bancrofti that when an infested mosquito bites a human being the filaria larvae bore through a thin portion of the labium known as Dutton's membrane, and more rarely other thin portions of the proboscis, actively penetrate the skin of the individual attacked, and reach the lymphatic system where they complete their development to maturity.

Both anopheline and culicine mosquitoes can serve as intermediate hosts of Filaria bancrofti including the foloowing species:

Anopheline mosquitoes.

Myzomyia rossi
Pyretophorus costalis
Myzorhynchus sinensis
Myzorhynchus barbirostris
Myzorhynchus peditaeniatus.

Culicine mosquitoes.

Culex pipiens	Stegomyia calopus
Culex fatigans	Stegomyia gracilis
Culex skusei	Mansonia uniformis
Culex gelidus	Mansonia annulipes
Culex sitiens	Scutomyia albolineata
Culex albopictus	Taeniorhynchus domesticus.

Besides those named about a dozen other species of mosquitoes have been tested as hosts of Filaria bancrofti with negative results, or with results showing that the parasites would only develop imperfectly. Fleas, lice, and Stomoxys have been tested with negative results.

Prophylaxis against Filaria bancrofti evidently consists in measures similar to those employed in malaria eradication with reference to mosquito control.

Filaria (Loa) loa (Cobbold, 1864).

This parasite of man is a West African species. It has been brought to America in the slave trade but never established in the New World.

World. The adults live usually in the subcutaneous connective tissue but have been found elsewhere in relation with the serous membranes of the abdominal and thoracic viscera. They move about from place to place and can change their location rather rapidly; for example, one of these worms has been seen to cross the bridge of the nose beneath the skin within a period of an hour or two. In their progress beneath the skin in various parts of the body they give rise to transient edematous areas known as Calabar swellings. The larvae produced by the females enter the blood stream where they are found in the peripheral vessels during the day time, contrary to the habits of the larvae of Filaria bancrofti. Because of this characteristic periodicity of the larvae Filaria loa has been also named F. diurna. The larvae of F. loa are provided with a sheath relatively much longer than that of the larvae of F. bancrofti.

Experiments with various anopheline and culicine mosquitoes, and Glossina palpalis have given negative results as to the possibility of these insects acting as intermediate hosts. From Leiper's (1913) researches, it would appear that a species of Chrysops (probably C. dimidiata or C. longicornis) acts as the intermediate host of Filaria loa, the larvae undergoing their development in the salivary glands of the insect. According to Ringenbach and Guyamarc'h (1914), the intermediate host in the Congo is Chrysops centurionis. Kleine (1915) in West Africa found 32 out of 600 Chrysops examined to be infested with larval nematodes which he took to be the larvae of F. loa though he does not give sufficient evidence to support his claim.

Filaria demarquayi Manson, 1895.

This parasite, generally considered identical with Filaria juncea and F. oggardi, occurs in man in the West Indies and in British Guiana. The adult has been found in the mesentery and under the peritoneum of the abdominal wall. The first-stage larvae occur in the blood stream. Their appearance in the circulation is not periodic. According to Low (1902) the larvae can be developed to the so-called "sausage" stage in Stegomyia calopus. Experiments with Anopheles albipes, Culex taeniatus, C. fatigans and other mosquitoes, fleas, and ticks failed to result in any development of the larvae. Fülleborn (1908) was able to develop the larvae to the sausage stage in Anopheles maculipennis and Stegomyia calopus, but no development occurred in the tick, Ornithodoros moubata. Further investigations are necessary to determine what insects serve as intermediate hosts for F. demarquayi.

Filaria philippinensis Ashburn & Craig, 1906.

The adult stage of this parasite of man is unknown. The first-stage larvae occuring in the blood of man are morphologically identical with those of Filaria bancrofti. Unlike the latter, however, they show no periodicity. Ashburn and Craig (1907) have shown that the larvae will undergo development in mosquitoes (Culex fatigans) similar to that of the larvae of F. bancrofti. It is questionable whether F. philippinensis should be recognized as a distinct species.

Filaria cypseli Annett, Dutton & Elliot, 1901.

The adult stage of Filaria cypseli occurs in the subcutaneous tissue of the head of the swift, Cypselus affinis, also beneath the subcranial fascia. The embryos or first stage larvae occur in the lymph and rarely in the peripheral blood of infested birds. Dutton (1906) has described various larval stages of the parasite which he finds in an undetermined species of bird-louse belonging to the subfamily Leiothinae that occurs on swifts. The first stage larvae as it is found in the blood of the bird and the stomach of the louse is provided with a sheath as in various other species of Filaria. This sheath is lost and the larva probably soon penetrates the stomach wall. The next stage of the parasite is found in the fat-body of the louse as are two later stages described by Dutton. The last stage of development seen by him is found free in the body cavity and this is probably the stage in which the parasite is transferred to the bird; whether as a result of ingestion of the louse by the swift, or as a result of the active migration of the worm from the louse while the insect is engaged in biting, has not been determined.

Filaria martis Gmelin, 1790.

Filaria martis (or Filaria quadrispina) according to various writers occurs in its adult stage beneath the skin and in the abdominal and thoracic cavities of Mustela foina. Baldasseroni (1909) has found Filaria embryos in the intestine of ticks (Ixodes ricinus) taken from a marten harboring the adult nematode, and he suggests that ticks may act as intermidiate hosts. As in the case of Acanthocheilonema grassi. Further evidence is necessary before ticks can be considered to play a part in the life history of Filaria martis.

Dirofilaria immitis (Leidy, 1856) Railliet & Henry, 1911.

This nematode sometimes erroneously listed as a parasite of man, lives in the right side of the heart and pulmonary artery of the dog. The larvae are found in the circulation, most numerous at night as in the case of Filaria bancrofti. As would be expected from the location of the adult parasite it may give rise to serious symptoms, and affected dogs commonly succumb to the disturbances which it causes. It is a troublesome parasite among hunting dogs in the Southern United States. Noé (1900) showed that the larvae of this nematode continue their development in certain species of mosquitoes when sucked up with the blood of infested dogs. In 24 to 36 hours after reaching the stomach of the mosquito the larvae pass into the Malpighian tubules, They undergo a certain growth and development in this location, and 11 or 12 days after reaching the mosquito they break out of the tubules, enter the body cavity, and migrate to the labium. From the labium of the mosquito they reach their final host, the dog, in the same manner as F. bancrofti reaches its human host, namely, by breaking through thin portions of the cuticle of the labium at the

time the mosquito is engaged in biting its victim. Mosquitoes infested with the larvae of D. immitis are commonly killed by the parasites owing to their destructive action on the Malpighian tubules, Noé having observed that only about half the mosquitoes that become infested survive. In Italy the common intermediate hosts appear to be Anopheles maculipennis, A. bifurcatus, Myzorhynchus pseudopictus, and Myzomyia superpicta among anophelines; culicines, according to Noé, such as Culex penicillaris, C. malariae, and exceptionally C. pipiens, can also act as intermediate hosts.

Dirofilaria repens Railliet & Henry, 1911.

In the adult stage this nematode which is a very similar parasite to D. immitis occurs in the subcutaneous connective tissue of the dog. Its larvae enter the blood stream whence they are liable to be ingested by blood-sucking insects. According to Bernard and Bauche (1913) the yellow fever mosquito Stegomyia calopus acts as the intermediate host. These investigators while admitting that other species of mosquitoes might act as intermediate hosts of D. repens, found that S. calopus best fulfilled the natural conditions for the transmission of the parasite, and their experiments were carried out with this species of mosquito. They followed the various stages in the development of the larval nematodes in mosquitoes fed experimentally upon infested dogs. About 2 days after the mosquito has been fed the nematode larvae leave the lumen of the alimentary tract and penetrate into the Malpighian tubules where they undergo most of their growth and development. By the eighth day the larvae may be found in some cases to have migrated into the body cavity and thoracic muscles and the last stage of development in mosquitoes may be found in the proboscis as early as the ninth day. Six young dogs (10 days old) were submitted to the bites of S. calopus (fed 10 to 15 days previously on infected dogs) every morning for fifteen days. Six young dogs of the same age were kept as controls, not exposed to mosquito bites. The bitten dogs all died within thirty days. Ecchymotic spots were found beneath the skin at the points of the mosquito bites, but no filarias were discovered. The other dogs all survived the experiment. Under natural conditions the youngest dogs found infested with D. repens by Bernard and Bauche were at least a year old, hence the writers conclude that the development of the parasite is very slow. Although they did not succed in completing their experiments by recovering the adult stage of the parasite in dogs following bites by infected mosquitoes it appears safe to conclude that the D. repens is transmitted by mosquitoes in a manner similar to that in which D. immitis is transmitted.

Acanthocheilonema perstans (Manson 1891) Railliet, Henry & Langeron, 1912.

This parasite occurs in man in tropical Africa and British Guiana, the adults in the intraperitoneal connective tissue and fatty tissue of the abdominal viscera and pericardium, and the first-stage larvae in the blood stream. The larvae exhibit no periodicity in their appearance in the circulation, the name perstans having reference to this fact.

Christy (1903) has suggested that Ornithodoros moubata may act as the intermediate host of Acanthocheilonema perstans. Wellman (1907) has reported that the larvae of this parasite are taken up by Ornithodoros moubata and according to his statements develop very slowly in this tick, advanced stages not being found until more than two months after infection of the tick. The suggestion made by Feldmann (1905), influenced by Bastian (1904) that the larvae of A. perstans may pass out of the body of the tick with its eggs into bananas and afterwards be swallowed with this fruit by human beings is a mode of infection which requires no consideration as a possibility without more supporting evidence than has yet been advanced.

Hodges (1902) observed Filaria larvae in the thoracic muscles of mosquitoes (Panoplites sp. and Stegomyia calopus) three days after they had been fed on perstans blood. Low (1903) was able in one case to obtain development of perstans larvae to the sausage stage in a mosquito (Taeniorhynchus fuscopennatus) Fülleborn (1908,1913) obtained a similar development in Anopheles maculipennis. Fülleborn and Low obtained negative results with various species of mosquitoes, sand fleas, lice, and simulids.

Acanthocheilonema grassii (Noé, 1907) Railliet, Henry & Langeron, 1912.

The adults of this nematode occur in the subcutaneous and intermuscular connective tissue and peritoneal cavity of the dog. The larvae produced by the females are unusually large, about twice as long and thick as the average filaria larva, and according to Noé (1907,1908) do not pass into the blood stream as is generally the case among the filarias. Noé assumed that the larvae are restricted to the lymphatic system, and accordingly concluded that the intermediate host would most likely be a tick or similar slow feeding ectoparasite. In fact he found nematode larvae corresponding to those of A. grassii in ticks of the species Rhipicephalus sanguineus a tick of common occurrence in regions where the dogs are infested with the nematode in question. Furthermore he states that all of the ticks attached to dogs infested with the nematode become infested with the larval worms. Additional evidence that R. sanguineus acts as the intermediate host is that the larvae in the ticks undergo growth and development, at least one molting period having been observed between successive stages. As R. sanguineus is a tick which falls to the ground to transform from the nymphal to adult stage the necessary opportunity is afforded from the transmission of A. grassii from one dog to another. Noé remarks that the nymph of this tick ingests large quantities of lymph. The larval nematodes taken in with the ingested lymph penetrate the intestinal wall into the body cavity where they undergo the development necessary before they are ready to be returned to the definitive host, after transformation of the nymphal tick to the adult stage. Noé believes that the dog becomes infected during the initial phase of attachment of the adult. He also suggests that adult males which unlike adult females may pass from one host to antoher are capable of acquiring infection from one dog and transferring it to another. He found as many as 22 larvae of A. grassii in one male tick. Noé is of the opinion that

the larvae escape through thin portions of the cuticle of the mouth parts of the tick and thus reach the final host in a way similar to that followed by the larvae of D. immitis and other filarias transmitted by mosquitoes.

It is of interest to note that Grassi and Calandruccio (1890) found larval nematodes in Rhipicephalus siculus (= R. sanguineus) which they identified as the larvae of Filaria recondita (= Acanthocheilonema reconditum). Noé thinks that these larvae may have been A. grassii rather than A. reconditum.

Evidently further investigations into the life-history of A. grassii are necessary before ticks can be accepted as the intermediate hosts of this parasite.

Acanthocheilonema reconditum (Grassi, 1890) Railliet, Henry & Langeron, 1912.

This nematode is a parasite of the dog and in the adult stage has been collected from adipose tissue in the neighborhood of the kidney. According to Grassi and Calandruccio (1890) the first-stage larvae occur in the blood stream and are the so-called Haematozoa of Lewis which have been seen by many observers, first by Gruby and Delafond (1843), afterwards by Lewis and others. Apparently, however, the larvae seen by Grassi and Calandruccio as well as those known as Lewis's haematozoa are in reality the larvae of Dirofilaria repens. Grassi and Calandruccio describes various stages of nematode larvae found in fleas. (Ctenocephalus canis, C. felis, and Pulex irritans) and in a tick (Rhipicephalus siculus = R. sanguineus) as developmental stages in the life history of A. reconditum. According to Noé (1907, 1908) the larvae found in R. sanguineus by Grassi and Calandruccio were probably those of Acanthocheilonema Grassi.

Owing to the confusion existing with reference to the identity of the parasites that Grassi and Calandruccio studied the species to which the larval nematodes observed in fleas belong is uncertain. Grassi and Calandruccio's experiments can not be considered conclusive so far as concerns the life history of A. reconditum.

Setaria labiato-papillosa (Alessandrini, 1838) Railliet & Henry, 1911.

The adults of this nematode are common parasites in the peritoneal cavity of cattle in various parts of the world including the United States. The larvae enter the blood stream, and Noé (1903) identifies certain larval nematodes found in Stomoxys calcitrans as belonging to this species. That this fly actually serves as the intermediate host, however, remains to be proved.

The possibility is not excluded that Noé mistook Habronema larvae for the larvae of S. labiato-papillosa.

Oncocerca.

Several species of this genus of nematodes have been described. Oncocerca volvulus in the adult stage occurs in nodular tumors beneath the skin of man in Africa. O. gibsoni causes worm nodules in the brisket and other locations in cattle in Australia. Two species occur in cattle in the United States: one undetermined species is found in relation with the ligaments of the legs and neck, the other (O. lienalis) is found in the gastrosplenic ligament. Oncocerca larvae have not been found in the blood stream but may be recovered from the lymph spaces in the neighborhood of the adult worms. The intermediate hosts of these parasites are unknown but biting insects have been suspected. The results of experiments have been negative. Brumpt (1903) has seggested the possibility that Glossina palpalis acts as intermediate host of O. volvulus.

Other nematodes.

Different investigators have recorded the occurrence of larval nematodes of unknown species in various insects. Usually these have been very poorly described and it is questionable in many cases whether if found again they could be recognized as the same forms. Some of them may be the larval forms of nematodes whose adults are already known as parasites of higher animals. Among such larvae of uncertain identity may be mentioned Filaria geotrupis in the abdominal cavity of Geotrypes stercorarius (possibly the larva of Physocephalus sexalatus), Filaria ephemeridarum in the abdominal cavity of the larvae of Ephemera vulgata and Oligoneuria rhenana, Filaria rytipleurites (of Magalhães, 1900, not Deslongchamps, 1824) in the abdominal cavity of Periplaneta americana, Filaria stomoxeos in Stomoxys calcitrans (possibly a Habronema larva), Mastophorus echiurus and Cephalacanthus monacanthus in Tenebrio molitor (probably larvae of Protospirura muris), Mastophorus globocaudatus and Cephalacanthus triacanthus in Geotrypes stercorarius (possibly larvae of Physocephalus sexalatus).

Mermithidae.

These worms which resemble the nematodes and are usually grouped with them are not known to be of importance in medical zoology. One species of uncertain identity is of interest however, as it is the so-called "cabbage snake" whose presence among the leaves of cabbage has alarmed people who have encountered it. This worm like others of the same family, undoubtedly passes through a portion of its development in the body of an insect probably one of the common caterpillars that attack cabbage. Similar worms have been found in apples.

GORDIACEÆ, OR HORSE-HAIR WORMS.

The Gordiacea or horsehair worms (as which they are popularly known from the superstitious belief that they are animated horse hairs)

are of medical interest because several species have been recorded as parasites of man. They gain entrance to the alimentary tract by being swallowed in drinking water. The adults are of not uncommon occurrence in springs and other surface waters. When swallowed by human beings they are usually soon vomited up but they have in some cases apparently survived in the intestine for several months before they were finally expelled. In some species and probably in all, insects serve as hosts for the larval stages. The adults deposit their eggs in the water in which they live. The larvae hatching from the eggs enter aquatic insect larvae, which may later be devoured by carnivorous water insects. In the latter the worms undergo their development until they have reached or approached maturity when they burst out of the infested insect and escape into the water. The following species of Gordiacea have been recorded as accidental parasites of man: Gordius aquaticus, G. chilensis, Paragordius varius (a common American species), Paragordius Tricuspidatus, Parachordodes tolusanus, Parachordodes violaceus, Parachordodes pustulosus, and Chordodes arbestris.

ACANTHOCEPHALA OR THORN - HEADED WORMS.

This highly specialized group of parasites, commonly classified in the Nemathelminthes, with which it has little in common beyond a superficial resemblance in the general shape of the body, has been but little studied. Most of the known species are parasitic in birds.

Macracanthorhynchus hirundinaceus (Pallas, 1781) Travassos, (1916.

This worm in the adult stage(sometimes called the giant thorn-headed worm) is a common parasite of the intestine of the pig and is said to occur as a parasite of man along the river Volga. Its eggs pass out of the body of the host in the feces. Swallowed by certain insects (larvae of Melolontha vulgaris, Cetonia aurata, Lachnosterna arcuata, and Diloboderus abderus) the eggs hatch, and the larvae develop into an intermediate stage, which in turn completes its development to maturity when the infested grub is eaten by a pig.

Moniliformis moniliformis (Bremser, 1819) Travassos, 1915.

This parasite in its adult stage (sometimes called the beaded thorn-headed worm) is of common occurrence in the intestine of rats and other rodents in tropical and subtropical regions, and has been found in man in Italy. The life cycle is similar to that of the giant thorn-headed worm except for the difference in hosts. According to Grassi and Calandruccio (1888), Blatta germanica acts as an intermediate host. According to Magalhaes and also Seurat (1912), the usual intermediate host is a cockroach (Periplaneta americana).

COMPENDIUM OF PARASITES ARRANGED ACCORDING TO INSECT HOSTS:

Coleoptera:

Acis goryi
Spirocerca sanguinolenta

Acis spinosa
Hymenolepis diminuta

Aphodius castaneus
Arduenna strongylina

Aphodius coloradensis
Gongylonema scutatum

Aphodius femoralis
Gongylonema scutatum

Aphodius fimentarius
Gongylonema scutatum

Aphodius granarius
Gongylonema scutatum

Aphodius vittatus
Gongylonema scutatum

Blaps sp. (near appendiculata)
Spirura gastrophila

Blaps mucronata
Moniliformis moniliformis

Blaps strauchi
Spirura gastrophila

Cetonia aurata
Macracanthorhynchus hirundinaceus

Copris hispana
Spirocerca sanguinolenta

Diloboderus abderus
Macracanthorhynchus hirundinaceus

Geotrypes douei
? Gongylonema mucronatum

Geotrypes douei, cont.
Spirocerca sanguinolenta
Physocephalus sexalatus

Geotrypes stercorarius
Cephalacanthus triacanthus
Filaria geotrupis
Mastophorus globocaudatus
? Physocephalus sexalatus

Gymnopleurus mopsus
? Gongylonema mucronatum

Gymnopleurus sturmi
? Gongylonema mucronatum
Spirocerca sanguinolenta

Ilybius fuliginosus
Haplometra cylindracea

Lachnosterna arcuata (naceus
Macracanthorhynchus hirudi-

Melolontha vulgaris (naceus
Macracanthorhynchus hirudi-

Onitis
Onitis irroratus
? Gongylonema mucronatum

Onthophagus spp.
Onthophagus spp.
Arduenna strongylina
Spirura gastrophila

Onthophagus bedeli
? Gongylonema mucronatum
Physocephalus sexalatus

Onthophagus hecate
Gongylonema scutatum

Onthophagus nebulosus
Physocephalus sexalatus

Onthophagus pennsylvanicus
Gongylonema scutatum

Coleoptera:

Scarabaeus (Ateuchus) sacer
?Gonylonema aucronatum
Physocephalus sexalatus
Spirocerca sanguinolenta

Scarabaeus (Ateuchus) variolosus
Physocephalus sexalatus
Spirocerca sanguinolenta

Scaurus striatus
Hymenolepis diminuta

Tenebric molitor
Cephalacanthus monacanthus
Gonylonema neoplasticum
?Hymenolepis diminuta
?Hymenolepis microstoma
Lactophorus echiurus
Protospirura muris

Water beetles
Pleurogenes medians
Prodotocus confusus

Lepidoptera:

Asopia farinalis
Hymenolepis diminuta

Hydrocampa nymphaeata
Trematode

Diptera:

Anopheles bifurcatus
Dirofilaria immitis

Anopheles claviger
Trematode

Anopheles maculipennis
Acanthocheilonema perstans
(incomplete development)
Dirofilaria immitis
Filaria immitis
(incomplete development)
Trematode

Anopheles rossi
Trematode

Chironomus plumosus
Lecithodendrium ascidia

Chrysops sp.
Filaria (Loa) loa

?Chrysops centurionis
Filaria (Loa) loa

?Chrysops dimidiata
Filaria (Loa) loa

?Chrysops longicornis
Filaria (Loa) loa

Culex albo fictus
Filaria bancrofti

Culex fatigans
Filaria bancrofti
Filaria philippinensis
Trematode

Culex gelidus
Filaria bancrofti

Culex malariae
Dirofilaria immitis

Culex penicillaris
Dirofilaria immitis

Culex pipiens
Dirofilaria immitis
Filaria bancrofti

Diptera:

Culex sitiens
Filaria bancrofti

Culex shusei
Filaria bancrofti

Mansonia annulipes
Filaria bancrofti

Mansonia uniformis
Filaria bancrofti

Musca domestica
Chounotaenia infundibulum
Habronema muscae

Myzomyia rossi
Filaria bancrofti

Myzomyia superpicta
Dirofilaria immitis

Myzorhynchus barbirostris
Filaria bancrofti

Myzorhynchus peditaeniatus
Filaria bancrofti

Myzorhynchus pseudopictus
Dirofilaria immitis

Myzorhynchus sinensis
Filaria bancrofti

Panoplites sp.
Acanthocheilonema perstans
(incomplete development)

Pyretophorus costalis
Filaria bancrofti

Scutomyia albolineata
Filaria bancrofti

Stegomyia calopus
Acanthocheilonema perstans
(incomplete development)
Dirofilaria repens
Filaria bancrofti
Filaria demarquayi
(incomplete development)

Stegomyia gracilis
Filaria bancrofti

Stomoxys calcitrans
Filaria stomoxeos
?Habronema muscae
?Setaria labiato-papillosa

Taeniorhynchus domesticus
Filaria bancrofti

Taeniorhynchus fuscopennatus
Acanthocheilonema perstans
(incomplete development)

Aphaniptera:

Ceratophyllus fasciatus
Hymenolepis diminuta
?Hymenolepis nana

Ctenocephalus canis
?Acanthocheilonema reconditum
Dipylidium caninum
Hymenolepis diminuta

Ctenocephalus felis
?Acanthocheilonema reconditum
Dipylidium caninum

Pulex irritans
?Acanthocheilonema reconditum
Dipylidium caninum
Hymenolepis diminuta

Xenopsylla cheopis
Hymenolepis diminuta
?Hymenolepis nana
?Proharriusa uncis

Wallophyta:

Leicthinus (?genus ?species)
Filaria cymbali

Trichodectes canis
Dipylidium caninum

Neuroptera:

Amaroli[illegible] nervosa
Allocreadium isoporum
Opisthioglyphe rastellus

Chaetopteryx villosa
Allocreadium isoporum

Cloeon [illegible]
?Opisthioglyphe rastellus

Drusus trifidus
Trematode

Esitheca
Corrodora cymaciues
Gorgodera [illegible]
Gorgodera varsoviensis

Limnophilus flavicornis
Opisthioglyphe rastellus

Limnophilus griseus
Opisthioglyphe rastellus

Limnophilus lunatus
Opisthioglyphe rastellus

Limnophilus rhombicus
Opisthioglyphe rastellus

Mystacides nigra
Trematode

Notiobia ciliaris
Trematode

Paryphostomum sp.
Lecithodendrium chilostomum

Phryganea grandis
Trematode

Phyacophila nubila
Trematode

Sialis lutaria
Trematode

Orthoptera:

Aeschna
Prosotocus confusus

Agrion
Corrodera pagenstecheri
Gordioders varsoviensis
Pleurogones medians

Anisolabis annulipes
Hymenolepis diminuta

Blattella germanica
Gongylonema neoplasticum
Gongylonema scutatum
(experimental infection)

Oligoneuria rhenana
Filaria echemeridarum

Periplaneta americana
Filaria rytipleuritas
Gongylonema neoplasticum
Moniliformis moniliformis

Calopteryx virgo
Halipegus ovocaudatus
Pneumonoeces similis

Cordulia
Prosotocus confusus

Ephemera vulgata
Allocreadium isoporum
Filaria ephemeridarum
?*Onisthioglyphe rastellus*

Ephemeridae
Lecithodentrium ascidia

Periplaneta orientalis
Gongylonema neoplasticum
?*Spirocerca sanguinolenta*
Spirura gastrophila

Perlidae
Lecithodendrium ascidia
Trematode

Myriapoda,°

Fontaria virginiana
Hymenolepis diminuta

Glomeris limbata
Tapeworm larvae

Julus sp.
Hymenolepis diminuta

Julus guttulatus
Nematode larva

Acarina?

Ixodes ricinus
?*Filaria martis*

Ornithodoros moubata
?*Acanthocheilonema perstans*

Rhipicephalus sanguineus
?*Acanthocheilonema grassi*
?*Acanthocheilonema reconditum*

Isopoda:°

Porcellio laevis
?*Acuaria nasuta*

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This concludes the series of lectures. They are all now being revised for publication in book form, with the domestic and municipal viewpoint, rather than that of the army. Several new lectures not distributed in mimeograph form have been added.

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We will soon have all missing numbers run off and sent to those whose sets are incomplete according to our own records. If in a reasonable time you do not receive these missing numbers kindly write and they will be sent you. There will be a number of extra sets available for other persons interested.

W. Dwight Pierce,
Class Leader.